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Introduction

In 1994, The Rensselaerville Institute applied to the U.S. Environmental Protection Agency (EPA) for a cooperative agreement to explore real and perceived barriers and incentives that presently exist in the use of innovative wastewater pollution control and prevention technologies. Our focus included systems and technologies for meeting effluent guidelines of the National Pollutant Discharge Elimination System (NPDES) program. This funding request was approved under the Environmental Technology Initiative (ETI). ETI is an EPA-led, interagency initiative announced in President Clinton's first state of the union address on February 17, 1993. The goal of the ETI is to promote improved levels of health and environmental protection by accelerating the development and use of innovative environmental technologies, and to increase the global marketability of U.S. innovative environmental technology.

The Rensselaerville Institute has a 25-year history of working effectively with rural communities in helping to address water and wastewater problems. Our own experience has been that innovation has few strong forces that push, generically, for its introduction and adaptation in wastewater treatment. Unlike innovation in health care or computer science, consumers (e.g., community residents, local government officials, etc.) do not tend to believe that continual innovation is needed. Among those with a strong environmental perspective, for example, we have found far more people who are concerned about adequate funding for existing solutions than about discovering new technologies.

Few communities and industries faced with wastewater treatment needs think innovatively about new products. Rather, a wide range of factors encourage them to only use over and over again existing, conventional technologies, freezing out newer and more effective options. In fact, some communities are less concerned about ending up with an ineffective wastewater solution , as long as their actions can be defended by tradition and the mainstream of current practice, than they are with implementing a system that might solve the problem but call attention to something different and unproven.

This experience, coupled with our belief that breakthroughs are needed in both effectiveness and cost-reduction, prompted us to enter into a cooperative agreement with EPA and define the specific approach we wished to take. An early review of the

substantial written documentation on barriers to technology innovation suggested the need to look beneath generalized conclusions and recommendations in order to capture the more subjective but richer specific experiences of those who had "been there"--and the varied insights of those directly involved at the community, professional or regulatory level.

Our broader assumption is that optimal change points for the introduction of innovation in wastewater treatment are widely dispersed. Certainly**,** performance standards do not readily lend themselves to prescribing means. At the incentives level, EPA and other groups have found limited success in attempting to encourage innovation through grants programs. Given this experimental framework, we wished to develop insights that might prompt new activity from the widest variety of actors--engineering firms, inventors, mayors and city managers, venture capitalists, among others. It is our opinion that it is with these actors where innovation can be prompted. The largest question for the federal government is how best to enable and encourage innovation within a framework of compliance and environmental protection.

Our focus on capturing personal experiences reflects the belief that theory and practice can be distinct. In particular, we all hear a great deal about the barriers to innovation, but sometimes find that they are perceived more than real. Indeed, the barriers encountered by those who have actually undertaken efforts to introduce new technology can be very different from those reported to exist by people who study the problem but have never directly faced it. In many instances, the introduction of technology innovation is not a matter of infrastructure or of institutional programs but involves a willingness to engage in an entrepreneurial act. Indeed, the failure to appreciate this distinction is, itself, a barrier.

Our study was conducted using three specific qualitative research formats: case studies; critical incidents; and expert perspectives. The first two present "snapshots" of individual cases where innovative technology was applied in a given situation. The first, the case study, is somewhat like time-lapse photography by documenting the actions and perceptions of key players over time.

The second, the critical incident, is more like a still shot: it represents one critical moment in a given community's use of innovative technology which proved a pivotal point in the final outcome.

The studies were conducted both on-site and by telephone over a nine-month period. Most telephone interviews cited in the study required more than one phone conversation

with the contributor. Further, in all case studies and critical incidents, more than a single perspective was sought (e.g., community representative, government regulator, technology developer, consulting engineer, etc.). In each, direct quotes are cited, and have been reconfirmed to ensure accuracy and willingness to be quoted. Thus, the regulated community may perceive EPA or another regulatory body to be the barrier when in fact it is the statute itself that poses the barrier.

The accountings and perceptions of experience, and may or may not reflect a complete knowledge or appropriate interpretation of federal statute and regulation. Yet, the regulated community has historically been conditioned to a command-and-control mindset. Changing that mindset after 20 years is certainly possible, and will be a challenge to the Agency in the next decades. For example, the NPDES regulations do in fact include the flexibility needed to use alternative or innovative technology that the interviewee wishes to use, but he or she does not realize that such flexibility already exists within the regulations. Federal NPDES regulations do not include requirements that a particular technology be used. While it is true that the effluent limitation guidelines were developed based upon a survey of the capabilities of different industry sector-specific treatment technologies, there is no continuing obligation that permittees use these technologies. However, many States and localities (such as the Departments of Public Health) do require that plans and specifications for treatment facilities to be constructed be approved by the State.

Further, statutes that prove to be barriers may in fact be a result of Congressional action through the Clean Water Act; therefore they are not under direct control of the U.S. EPA to change or modify; the EPA's job by law is only to enforce the statute.

With completion of the initial research, five focus groups were convened to review initial draft case studies and critical incidents as well as to comment on the presentation and format of perceptions and perspectives attained. The first was an informal focus group of key EPA personnel who have developed extensive expertise and experience with the use of innovative wastewater technology. This group was convened early in the process to review and respond to the format which the Institute was using to collect the qualitative data and perceptions that comprise this report.

The second and third focus groups convened experts from throughout the U.S. representing the various stakeholder groups: Regional and State government, public

utilities in the regulated communities, consultant engineers, academia, and community representatives. These two focus groups were asked to consider the report's introductory section entitled "Summary of Barriers," and to comment on that section: adding, deleting, and modifying findings as they felt appropriate based on their personal experiences and perspectives. The final two focus groups received the same section of the report, and at their meeting, were given a verbal review of the outcomes from the first two focus groups. These second-set focus group participants were then asked to make suggestions and recommendations on ways to overcome the barriers identified. They were also requested to discuss existing or potential incentives that might encourage increased consideration and use of innovative technology for wastewater pollution control and prevention.

Interviews and references are listed at the end of each case study and critical incident throughout the document. A summary review of the latter four focus group responses and suggestions for change is presented in Chapter 7. (This chapter is followed by a list of the participants for all four focus groups.)

1. Summary of the Barriers

There is an abundance of literature and research which investigates and analyzes barriers to technology innovation. The barriers which are relevant to wastewater treatment technologies can be condensed into the following areas: aversion to risk; lack of early trials and credible data; lack of sufficient technology transfer; barriers created by state and federal regulations; and inadequate funding. Each of these barriers are discussed below.

Aversion to risk

By definition, "innovative" technology is unproven technology which inherently involves risk. With wastewater treatment technologies, the risk can be one of complete failure, or more likely, one where the technology works but does not work well enough to meet the effluent requirements required for that community. Often, modifications to the system may resolve the problem, but in some cases, the entire system ends up being scrapped and replaced with a more conventional approach. Both approaches can be extremely costly and have devastating financial repercussions to the community or industry. Smaller, local companies and rural communities are often particularly hit hard if trial of an innovative approach fails. Small communities have fewer households to support the expense of a sewage treatment plant, and the residents generally have lower incomes as compared to more urban areas. In fact, some of these small communities state that they do not want to spend any money on sewage treatment, and they certainly don't want to be part of an experiment that might fail. Yet, these communities are the ones most commonly out of compliance and are often ideally suited to take advantage of the cost-saving features that some non-conventional methods offer through innovative and alternative on-site treatment systems.

Many consulting engineers perceive themselves to be at considerable legal and financial risk in trying something which is not totally "proven" technology. Failure (or the appearance of failure) can irreparably damage their professional reputation or that of their firm. Consultants justifiably fear negative publicity, where media reporters can misconstrue or mislead the public with sensationalized stories written in order to "sell" news. Regulators and local officials (such as mayors or town board members) who face the fiscal consequences, negative publicity and the political ramifications which often result from a failed system also perceive themselves at risk.

The above stakeholders each fear the lawsuits that could be filed against them. These liability concerns have resulted in time-consuming (and expensive) battles between attorneys representing their clients' best interests and those seeking protection from liability. With regard to the liability issue, the state of Pennsylvania requires the inventor or sponsoring consulting firm to post bond and obtain a special experimental permit when initiating an innovative (unproven) technology at a municipal wastewater treatment plant.

Risk is reality when applying new, unproven technology. To some extent, risk can be managed more effectively by the creation of demonstration project sites and by technology transfer of experience that already exists in another location. One key factor that must be addressed is time. In most areas of application, new technologies have a five to ten year period of early applications and refinements. Rarely are they expected to perform to high standards immediately at the point of implementation. Indeed, early failures are seen as critical milestones for learning on the road to success.

In water treatment, by contrast, the timetable is short. The "Innovative/Alternative" (I/A) grants program of EPA gave a community only one year to replace an old technology with a new one in order to reach compliance. The three-year compliance schedule on permits is somewhat less constraining. All told, incentive for staying power and "work outs" of technologies with promise is compromised by the timeframes allowed. The inclination of most sources and stakeholders--communities, consulting engineers, etc.--is for an early exit if the new technology falls short of permit requirements in the first test of application.

Another factor in the risk picture is the lack of offsetting risk with rewards for innovators intent on finding new approaches. Companies with new products in this field, for example, know that even when the technology is "proven," it will take years to gain a significant share of the market because of the risk perceived by critical stakeholders. One reason for the perceived risk is the condition of a strong intermediary: the consulting engineer. Unless the consulting engineer believes that the new technology provides assurance equivalent to that of existing technologies, the new technology will most likely not be recommended to municipal and industrial clients. The consulting engineer is far more likely to fall back to known, proven technologies that contain acceptable levels of risk - even if it is thought that an innovative technology might work in a given situation.

Lack of early trials and credible data

The lack of credible performance and cost data produces one of the largest barriers in implementing innovative technologies. Without scientifically collected data which support the application of an innovative system, the risk of failure overwhelms the potential user and the liability issues become intensified. The understanding of a specific innovative technology's advantages appears to vary among state and federal permit writers, regulators and private consultants. States with an authorized NPDES program have permit writers at the State level; currently there are 41 authorized states. States with no authorized NPDES programs must issue discharge permits through their EPA Regional offices.) This has resulted in variations in permit decisions across the nation in the application of Best Professional Judgment (BPJ). Moreover, many engineering consultants hesitate to recommend a new technology labeled as "innovative" because of the extra work and delays involved in the permitting decisions as well as the added expense to produce verifiable data and results on the new technology.

It must be noted here that under the NPDES program, the permitting authority is not concerned with the type of technology a permittee choses to meet compliance as long as the permittee meets the limit. The requirement of a particular reference technology is a "perceived" barrier by some of the participants in this study; in actuality the Federal and State NPDES regulations provide flexibility for trying innovative and alternative technology since the regulations do not require that a particular technology be used.

There are private consultants in wastewater engineering and design who have obtained expertise in some form of innovative technology through their own experiences in installing such systems. However, we found that the degree of support among consultants for that same technology varies widely due to the lack of demonstration projects and solid information about the use of the new technology in their state or hydrogeologic regions. For example, the use of constructed wetlands for wastewater treatment has existed for decades in the midwest, south and southwest, but is just now being demonstrated in the northeast where it is still considered an "innovative" technology. Wetland experts in the northeast found that they needed to educate their own state regulators about the effectiveness of natural wetland treatment in addition to "selling" their client on its application to solve the community's problems.

Furthermore, some state regulators admit that they resist giving support to new

technologies. In Vermont, the manager of the Wastewater Discharge Unit complained that private business entrepreneurs want permits to try new processes without proper documentation and demonstration. Their proposals have generally not gone through the accepted peer review process.

The academic world is always searching for research opportunities. Yet, academics note that while there are currently many federal laboratories sponsoring research for government agencies, none is dedicated to wastewater treatment research.

The research that is being conducted on wastewater treatment at universities and other not-for-profit institutions is perceived as being done with little coordination or focus on national need (Government Accounting Office, 1994). There is also an abundance of information that is collected but never published; it leaves when people leave.

Several of the larger U.S. municipal treatment plants have been known to provide pilot sites for innovative technologies which can be applied directly to solving a problem at a particular plant. Innovative systems and processes can provide critically important cost-saving measures, where problems are magnified by the size of the plant. These pilots enable the product developer or sponsor to obtain credible data, which may be enough to get the innovative technologies started commercially. However, these pilot studies are limited to the needs of that plant.

An additional application issue comes from the distinction between *invention* (creating a new approach) and *innovation* (testing and applying that approach). In wastewater treatment, some of the most promising approaches are closely held by inventors who are not skilled--and sometimes not interested--in such applied tasks as early capitalization and field testing. The innovative function is in equally short supply as are the sites on which applications can be tested.

A final problem comes from a lack of clarity about what kinds and levels of testing are required for a technology to be considered in compliance with standards--which is the "bottom line" for new technologies in this area. The balance point between anecdotal observations and informal documentation on the one hand and ten years of "hard data" on the other is not well struck. As a result, in the absence of incentives to counterbalance the risks defined above, the default is toward rejecting most technologies perceived to be "unproven."

Lack of sufficient technology transfer

Technology transfer cannot occur if demonstration sites are not available to collect meaningful data to validate the efficacy of innovations. In its *1989 Report to Congress*, the U.S. EPA concluded that the Innovative/Alternative (I/A) incentive program (funded under the Construction Grant program) was "tremendously successful at promoting the development and application of more cost-effective, environmentally sound wastewater treatment technologies, especially in small communities." However, the report also acknowledged concerns about whether I/A technologies would continue once the funding shifted to the State Revolving Fund (SRF) program. The SRF allows for low- interest loans rather than grants. Compiling reports for effective technology transfer bears additional costs.

According to the U.S. General Accounting Office Report (1994), "While EPA has continued a limited number of technology transfer efforts, with severely reduced funding for wastewater treatment engineering, virtually no evaluation work has been done. Most of EPA's technical manuals are outdated (many are based on research done in the 1970's), and few technology transfer and training seminars have been held. Furthermore, officials of EPA's Office of Research and Development (ORD) claim that the virtual elimination of ORD's wastewater treatment budget has caused the agency to lose much of its expertise in innovative and alternative technologies. According to ORD officials, the agency may no longer be able to keep abreast of new developments, much less evaluate them and disseminate information about them." (pgs. 32-33).

In addition to the lack of funding to produce documents and provide seminars, there is no clearly defined method for information dissemination. The myriad of regulatory and technical support offices at both the state and federal levels can be confusing even to those who work within these systems. The research here suggests that potential innovative technologies which are being developed by entrepreneurs and supported by private business ventures may be slipping through the cracks. There is no system to locate and track private sources on a nationwide basis. Snowfluent™, a trademarked process prototyped for the first time in the state of Maine, exemplifies this problem. The only relatively easily accessible source of information about this system is the inventor, who is located in Canada.

Accessing EPA publications is carried out mainly by the National Technical Information Service (NTIS). NTIS is a self-supporting federal agency that actively collects, organizes

and disseminates scientific, technical and engineering information resulting from government sponsored research. NTIS' role was strengthened in 1991 by the passage of the American Technology Preeminence Act (Public Law 102-245), which requires all federal agencies to submit any federally funded reports to NTIS within 15 days. NTIS has made great strides in recent years to make these documents available through state-of-the-art technologies which include on-demand printing and networking through the FedWorld Internet address. Yet, for some, obtaining EPA publications can still be challenging, particularly for the private sector.

Locating EPA documents normally begins with a search (by subject) on the NTIS bibliographic database, made available through several commercial vendors. The cost of such a search by an non-government employee can easily cost over $50.00; comprehensive searches typically cost well over $100 (per search topic). Alternatively, a researcher can utilize the free CD-ROM version of the NTIS database available at many large research libraries. Most depository libraries and many universities provide this service to the public. The result, either way, is a bibliography with detailed abstracts on the specific subject keyed into the database. The next step involves procurement of documents selected from the bibliography. This can provide quick access to government documents through their on-demand printing system through telephone or electronic ordering, all at a fee which can be charged on a credit card. While some short documents cost only $17.50, most fall into the range of $27 to $66 each. Additionally, larger documents are split into two or three parts and must be purchased separately, doubling or tripling the cost. Turning to the depository libraries allows one to obtain government documents *selectively*. However, some of these documents are normally available only on microfiche. Therefore, there is no guarantee that any particular library will have the documents desired, and, if they do, the researcher must be willing to read it on a microfiche reader or print out each page at a cost as high as $10/page.

Locating a government document in depository and university libraries has been hampered by the tremendous budgetary cutbacks in libraries in recent years. Many libraries, including the EPA Headquarters Library in Washington and the New York State Library in Albany, New York, have restricted public access to such public documents.

One cost-effective way of providing for technology transfer for innovative technologies is the dissemination of information through the Internet or through an electronic bulletin board or help line dedicated to provide technical advice.

Electronically, information about EPA and its databases is available through the EPA World Wide Web Server, and probably the most accessible manner in which to retrieve needed information for those who have access to the "Internet". This is the Agency's "home page", which gives information about the EPA mission and activities, rules regulations and legislation, grants and contracts, and other basic pertinent information. The address is http://www.epa.gov/. E-mail can be sent to internet_support @unixmail.rtpnc.epa.gov**.**

"Access EPA" is a comprehensive directory providing detailed descriptions of EPA's information resources including contact information for clearinghouses, databases, dockets, EPA scientific models, documents, EPA libraries and records programs. To access by modem, call the EPA online library system (919) 549-0720; "ibmpsi/"ols"/"a" (300-9600 baud, even parity, 1/2 duplex; 7 databits; 1 stop). Internet access to the same: telnet epalbm.rtpnc.epa.gov; "EPA information locators". EPA gopher server: gopher.epa.gov; "EPA information locators". GPO federal bulletin board system: (202) 512-1387. Voice help is available by calling (202) 512-1800. INFOTERRA/USA is a service which answers inquiries by providing U.S. government documents, technical reports, databases searches and bibliographies. It is part of the United Nations' environment programme's information exchange and referral service. Infoterra/USA responds to requests on any environmental topic at no charge. It can be accessed by phone (202) 260-5917; fax (202) 260-3923, or internet: library-infoterra@epamail.epa.gov. EPA's National Center for Environmental Publications and Information (NCEPI) is a major repository and distributor for EPA publications, with over 5,500 titles available in a variety of formats, including print and electronic. NCEPI's publications catalog is now available as a searchable database via the internet. Information provided in the catalog includes: title; EPA publication number (used for ordering); and address, phone, and fax information for placing orders. URL = http://www.epa.gov/epahome/catalog.html.

There is some funding for research from a few non-government sources. For example, the Water Environment Research Foundation (WERF) conducts a large share of the R&D for wastewater treatment in the United States. This group, whose parent organization is the Water Environment Federation, obtains a portion of its funding from EPA : $500,000 annually through 1995 (as a Congressional add-on). WERF is mainly supported through private donations, memberships and some corporate support. However, WERF estimates it can undertake only about 25% of the needed R&D activities due to funding constraints. In general, the private sector has invested very little in developing new technologies due in part to the level of uncertainty in the regulatory arena (U.S. General Accounting Office,

Sept. 1994).

The general belief in "public works" is that not much can be done without a grant or a budget appropriation. This applies not only to construction but to research and development and its dissemination as well. There is a more subtle side to this dynamic. The existing technologies for wastewater treatment have formed not only industry standards but public sector financing benchmarks as well. The result is that conventional approaches are well-anchored and financially justified by public sector allocations that have long ago learned to expand to respond to the question, "What will it cost?" Genuine cost control and a different starting point of affordability (e.g., "zero based costing" for wastewater treatment) are not strongly prompted. Without this, little urgency or energy is generated around the value of alternatives as is the case, for example, with public welfare. "Sewer reform" is not a public outcry.

Federal regulatory barriers under the CWA amendments

The Clean Water Act was first mandated in 1972 by Congress through the Federal Water Pollution Control Act Amendments which required EPA to set nationwide limits on the discharge of pollutants into surface waters from point (or end-of-pipe) sources. Congress required the EPA to set effluent guidelines for each major industry, taking into consideration economic and technical feasibility with an appropriate timetable. EPA initially focused its efforts on setting effluent guidelines for the conventional pollutants only: pH, Total Suspended Solids, Biochemical Oxygen Demand, coliform, oil and gas. Toxic chemicals were not initially considered. This resulted in the first of several important lawsuits brought against EPA by citizens and the Natural Resources Defense Council (NRDC). In 1977, 65 priority pollutants were added to the list of regulated pollutants under the CWA as a direct result of the NRDC lawsuit.

There have been many additional amendments to the CWA. Enforcement was tightened for stormwater runoff and oil spills (following the Valdez oil spill in Alaska) and for toxic chemicals. Other amendments were made to encourage pretreatment systems and pollution prevention. In 1977, an amendment encouraging the use of innovative technologies was promulgated under section 301(k), with minimal success. A lawsuit filed by the NRDC opposed the 301(k) Waiver for Innovation. (This is described below.) The additional layers of regulatory enforcement complicated by political conflicts produced barriers which stalled decisions to implement innovative technologies. During times of apparent indecision by regulatory agencies, stakeholders involved in wastewater treatment decisions became increasingly concerned that they could not look to the EPA to simultaneously provide regulatory flexibility and meet the demands of the public to ensure sufficient environmental protection. Those companies and communities that might have considered innovative or alternative technologies for wastewater treatment were left wondering what (and how much) cleanup they should do. Some did nothing. A representative from the Association of Metropolitan Sewerage Agencies described how some companies that *did* invest early in treatment systems may have been punished later by having to retrofit their treatment plants in order to meet more stringent effluent limitations which were later implemented, while competitors who waited were saved the expense.

The 301(k) innovation waiver program was analyzed in a detailed report prepared by Kerr & Associates. According to this report, innovation waivers were incorporated into both the Clean Air Act and the Clean Water Act as devices to promote the full development of new

and promising technologies. The CWA waiver under section 301(k) provided an extension of time for compliance during which companies could complete the technical development and installation of a new technology. The program, however, was fraught with problems, leaving far too many vulnerabilities to those who might otherwise consider innovative systems. For example, there was no provision for a "soft landing" (latitude for unpenalized recoup) for new technologies that narrowly missed their effluent limit. The extension of three years was far too short to realistically plan and implement unproven, truly innovative technologies. According to one engineering consultant from a nationally recognized firm, the extension of time that is allowed under 301(k) is probably adequate for conventional systems that need to be adapted to the local environment. However, innovative technologies present unknown and unanticipated results, which may require extensive analysis of the complex physical, biological and chemical systems simultaneously. All these factors interact, making quick identification and remediation of any particular inadequacy difficult at best within the allowed timeframe.

NRDC also had concerns about the 301(k) innovations waiver program. NRDC sued EPA over the final rule, hoping to tighten the language in order to minimize unjustified waivers. This lawsuit created controversies among state and federal regulators. In the final analysis, during the entire fourteen years from the creation of 301(k) in 1977 until its expiration in 1991, the waiver was hardly ever used.

The language of the CWA amendments themselves can create barriers simply because of ambiguity in definitions. For example, the definition of "innovative" remains elusive. The term seems to have evolved since the start of the CWA in 1972. During the earlier Innovative/Alternative incentive program, an important distinction was made between "innovative" technologies and "alternative" ones, resulting in a funding differential after 1981. The identification of "innovative" projects required case-by-case decisions by regulators for each application, often on a site-specific basis. Disagreements among regulators and consultants resulted. Deciding upon this designation was a very time consuming task for the already overwhelmed EPA staff. Therefore, state and federal regulators and engineering consultants involved in wastewater treatment decisions did not encourage or promote innovative technologies. Additionally, many states lacked the manpower and expertise necessary to evaluate innovative systems; as a result, in some states the I/A program had a very low priority.

In current literature, we find the term "innovative" used quite broadly. In the 1994 Government Accounting Office Report, the terms "alternative," "new," and "emerging" are

all treated synonymously. "Innovative" technologies are defined simply as "cutting edge and not fully proven." However, there is no clear distinction between the terms "innovative" and "alternative". In fact, a review of current technical journal articles tended to further broaden our terms to include "original," "state-of-the-art," "cutting edge," and "patentable" as key search terms.

The ambiguity and uncertainty in regulations is as potent a barrier as is complexity. Historically, unpredictable and volatile environmental shifts were one key explanation for a low incidence of venture capital and other investments in innovation for a given area. Currently, discussion concerning new language for the Clean Water Act suggests much uncertainty that will inhibit investment even if short term clarity on terminology is fully achieved (U.S. General Accounting Office, Sept. 1994).

All told, incentives are few for being a pioneer or even an early adapter to a new technology. At the financial level, there are assuredly long-term gains for new technologies once they are fully debugged and mass-produced, but early users rarely experience such gains. There are, in contrast, strong penalties for those who go first and falter.

Restrictive state and local regulations can create barriers

Many of those interviewed felt that the most significant barrier to trying innovative technologies for wastewater treatment is the strict time limitations imposed by both state and federal mandates. As mentioned above, the three year time extension allowed under the 301(K) innovation waiver was not adequate and was hardly ever used. Time constraints become an issue at the local and state levels, as well. A small village in upstate New York was unknowingly out of compliance with the effluent limit for their aging wastewater treatment plant, and the village was forced to enter into a consent order. A constructed wetland project was selected as the most cost-effective treatment system. While constructed wetlands are no longer considered "innovative" in other areas of the country, with New York's seasonal stresses, it *is* considered innovative. The consent order required the village to meet effluent guidelines in one year. A tight design and construction schedule was implemented in the fall of 1994, but the wetland flora needed to be planted during the spring of 1995, and required time to grow. The optimal level of growth had to occur within a one year window. The engineering consultant felt that local

regulators could have cut a little more slack, honoring the good faith effort being put forth by the community to demonstrate what promised to be a very effective and cost-efficient solution.

Our research indicates that some local and state regulations contain unrealistic constraints based on outdated codes which restrict the use of some innovations. The General Accounting Office Report (1994) found that these older codes were written for conventional systems and cannot readily accommodate modern technologies. For example, a mandate for manholes for the sewer collection system every so many feet is still required in some code books even though it is not appropriate with small diameter collection sewers**.** Fortunately, however, some states are now rewriting their codes to update them to newer technologies.

Also mentioned frequently was the lack of a "soft landing." (This was a concern at the federal level as well.) Innovative technologies may work, but not well enough, missing the effluent guidelines required in their discharge permit. Again, when a good faith effort is made, it was felt that regulators should offer some kind of assurance that plant owners would not be required to install an entire new [conventional] system when guidelines were almost met.

Some states are working to alleviate this concern and are beginning to adopt the "soft landing" philosophy for communities trying an innovative system. The state of Pennsylvania, for example, has fairly recently allowed for seasonal fluctuation in its water quality standards. The seasons are strictly defined for all areas of the state. A community in Pennsylvania was using the "submerged fixed film" technology and found it was unable to meet the effluent limitations for nitrogen when the water stayed cold longer than usual, due apparently to an abnormally cold receiving stream. The permit written for the community was able to alter the discharge permit by extending the definition of "winter," enabling the plant to be in compliance during those months of continued cold inflow in early spring. This "common sense" approach engendered a win-win situation for both the regulators and the community, and happened because it was based on a better understanding of the technology being tried and knowledge of the local ecosystem; further, it was backed by the "good faith effort" made by the community.

Many would agree that a "common sense" approach (within the constraints of regulatory flexibility) could be well suited to support the decisions made by water quality professionals and in effect reduce the load of the already overburdened regulatory staff at

both state and federal levels.

Other regulatory complications exist among different agencies within a state when certain types of innovative technologies are initiated. The most common difference occur between the state's department of health and its environmental regulatory agency. While the environmental regulatory agency(i.e. -NPDES permitting authority) does not require that a particular technology but used as long as the permittee meets the effluent limit (i.e.-performance based permitting), many States or localities do require that plans and specifications for treatment facilities to be constructed in a State be approved. Moreover, many on-site alternative treatment systems have a potential impact on groundwater or drinking water and may trigger department of health regulations, causing a restriction or prevention of the use of such innovative systems. On a positive note, however, there has been much discussion regarding integrated, cross-media regulations to alleviate some of these conflicts, thereby enabling the regulations to work in tandem to provide for a cleaner environment.

Inadequate funding

Budgetary reductions at all government agencies have resulted in the loss of programs and experienced staff nationwide. Both public and private industries are trying to "work smarter and leaner." Yet, tight budgets and personnel shortages have had a direct impact as to the extent to which EPA staff and state regulators can provide technical guidance and produce documents to support technology transfer.

The Construction Grant program, for instance, with its I/A incentive was terminated after fiscal year 1990 and was replaced by the State Revolving Fund (SRF) program. However, there are no mandates to provide any type of I/A incentive under the SRF. Some states have implemented their own incentive programs to encourage I/A activities in their states. It is unlikely though that any kind of modification/replacement program has been instituted in these states. Small, financially strapped communities don't want to put *any* money into a sewage treatment system, and would most likely be unwilling to take a chance on an innovative technology when the money must be paid back.

According to the Government Accounting Office (1994), "The State Revolving Fund is an effective alternative to the grant program, but it will not suffice to finance the nation's wastewater needs, especially the needs of the small communities." EPA research shows

that the cost of municipalities' unmet needs for wastewater treatment rose about $17.7 billion from 1988 to 1992, totaling $108 billion in 1992. Small communities' needs represent about 12% of this total, or about $13 billion. These small communities incur the highest level of risk in trying innovative technologies and are again, hit harder by the SRF program because of their limited revenue. Small communities are unable to compete with large communities for financing because of their comparatively poor credit rating since they cannot achieve the economy of scale. In making a loan, most states consider a community's ability to repay the loan with small communities being perceived as a greater credit risk than the larger communities. An exception is Wisconsin which is working to accommodate the needs of the more rural communities with fewer financial resources.

Congress authorized only $8.4 billion in the 1987 amendments as start-up funds for the SRF during the 1989 fiscal year. As stated above, it was estimated that $108 billion was needed in 1992 dollars. The competition for these funds would seem to force technological changes to encourage more cost-effective, energy efficient solutions to wastewater treatment. Yet, based on a series of interviews with the managers of the SRF, very few applications have been submitted for innovative or alternative systems. This would suggest that when financial support in the form of a grant disappears, so does the interest in taking the risk of innovation.

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2. Consultants and Industry Representatives Viewpoints on the Use of Innovative Technologies

The viewpoints in this section represent the perspectives of water quality professionals interviewed for this study. They offer insights into the real-life experiences and concerns regarding barriers and incentives for innovative technologies for wastewater treatment. They are not associated with one particular issue. Rather, each viewpoint serves to introduce discussions of barriers and incentives which are discussed in greater depth in the case studies and critical incidents.

These viewpoints are provided by: a consulting engineer for a large national firm; a constructed wetland expert; the president of a consulting firm which specializes in an innovative product; and finally, the manager of a non-profit foundation which advocates and provides wastewater research.

An engineering consultant's viewpoint on barriers to innovative technologies: Professor Glenn Daigger

The consulting engineer provides the professional expertise to independently evaluate different treatment technologies available, and recommend one which he or she feels will offer the best long-term solution at the lowest cost. These professional judgments assume a level of risk even with conventional, proven technologies. Unproven technologies add another layer of risk. Unless the consultant is also the inventor, the risks of selecting innovations often outweigh the benefits. Inventors, on the other hand, are highly motivated to sell the merits of their products in creative, energetic ways.

Professor Glenn Daigger, currently the Department Head of Environmental Systems Engineering at Clemson University, is well familiar with the additional risks of innovative technologies. As the former manager of CH2M Hill's "Office of Innovation," he has followed the research on the diffusion of innovation and the process of technology transfer. Daigger was instrumental in developing company policies for CH2M Hill which set guidelines for the analysis and selection of an innovative technology for many of their wastewater or stormwater projects. During EPA's Construction Grant Program, CH2M Hill wanted to position themselves as innovators. Daigger's guidelines cautiously supported this objective with careful consideration of a technology's merits and its ramifications.

Daigger found that if a community was sold on an innovative technology and it worked, the project would be completed smoothly and the client would remain supportive and thankful with CH2M Hill getting paid on time. However, when an unanticipated problem occurred, the client would be quick to blame the consultant and look for financial restitution. The firm's reputation would be at risk. Daigger found that regardless of how closely new products were evaluated, there would always be many factors at which his staff could only guess.

"These treatment systems are incredibly more complex then most people realize," explains Daigger. "I am truly amazed that we 'get it right' as often as we do."

Daigger compared an oil refinery to a wastewater treatment plant. "At the refinery, there is total control over the raw materials, the production rate, the specs in and the specs out," he explained. "These are all controllable *physical* factors. This contrasts sharply to a municipal sewage treatment plant. First, there is no control over the 'raw material,' which is the influent. Although the general parameters of BOD, pH, nitrogen and coliform are assumed to be within certain standard measurements, both individual homeowners and industries dump unknown chemicals and other contaminants into the sewers. When these intermix, combinations of chemicals can produce unanticipated, harmful effects on the plant."

Daigger further elaborated that the treatment technology itself is exceedingly complex. It must combine the physical, chemical and biological processes in a non-linear sequence rather than a linear one. Unforeseen consequences with conventional technologies must be dealt with for each new system installed. Design engineers expect a 'punch list' of minor electrical repairs, flow adjustments and the like.

"Conversely, installing an innovative technology requires us to explore the unknown," Daigger stated. "The non-linear design has a multiplicative effect when a new system is up and running and we then run into compliance problems. We can usually resolve whatever problems arise, given enough *time - but therein lies the problem*. This is the first barrier I'd like to describe: time. The NPDES permit program allows barely enough time for startup when the process is *known* and really understood. But when we're trying something brand new, we have to experiment with the equipment and the processes. If something does not work (for example, the nitrogen limits are not consistently met), we have to analyze the entire complex and all the processes which work together and interact with each other. This in itself requires more time to figure out the right combinations to

meet the permit effluent requirements."

Other barriers Daigger described deal directly with the permit process itself. A more effective system tends to penalize the discharger for doing too good of a job. For example, if a factory's limit is set at 30 BOD, but the innovative treatment system is able to achieve 10 BOD for the first couple of years, the regulator may then assume he or she is justified in permanently changing the limit to 10 BOD. However, what may not have been taken into account is the design of the treatment system and the substantial amount of variability in the influent over time. It's likely that the plant was designed with a 20 year capacity and met the 10 BOD because it was only running at half capacity. That's why it was able to achieve a higher level of cleanup than mandated by its permit. As the plant ages, the performance deteriorates, and ability to continue to meet more stringent standards drops.

Daigger concludes, therefore, with the recommendation that regulatory authorities should not set the effluent limitations by how well that plant has done without extrapolating the data over time and taking into account the aging of the plant, increased demand for wastewater treatment and the uncontrollable variabilities in the influent.

Other problems Daigger described when working on wastewater problems were differences in the ways the states interpreted the NPDES permit program. For example, "innovative technology" was defined differently among states, and yet it was a critical factor in being eligible for additional funding. Daigger found that not only were there real differences between states, but that regulatory styles and interpretations could change frequently within a given state, depending on which policy maker was in office. It was always a very dynamic and politically sensitive situation that had to be monitored continuously. **It should be noted that though the differences in State NPDES programs may be perceived by individuals such as professor Daigger as an inherent weakness to the NPDES program and a barrier to the encouragement of innovative technologies for wstewater treatment, the variations in State NPDES programs were based on Congressional intent. Congress intented that States be authorized to administer these programs and to incorporate appropriate variations to reflect State-specific situations, while assuring that certain minimum program requirements be in place.**

Daigger's interest in innovation led him to research at Iowa State University on the diffusion of innovation. The objective of these studies was to understand the means and

patterns by which innovative ideas spread. A case study was performed on the Agricultural Extension Service at Cornell University in New York state to support farmers and agriculturalists with educational programs developed from research done at Cornell. The technology transfer for the Extension Service was highly successful. According to Daigger, Iowa State's study on the diffusion of innovation gained national recognition; many colleges now teach entire courses on innovation.

Daigger used his growing understanding of the innovative process and of technology transfer to introduce and implement innovations for his clients. But he did this through *incremental* changes over a period of years, with each additional innovation being dependent upon the success of the previous one. According to Daigger, this was the key to successfully reducing barriers and eventually ending up with a completely new technology or process.

"There are basically two major categories of innovations: *breakthrough* innovations and *incremental* innovations. Incremental innovations consist of a series of small improvements made each time we install a plant. After a period of five years or so, there are enough incremental changes that we end up with major improvements as compared to five years ago, with far less risk of failure. This is way I would like to see the EPA support innovative projects in the future."

Daigger stated that he felt the earlier Construction Grant program, which provided financial incentives for innovative and alternative projects recognized and encouraged only breakthrough technologies. However, he feels that the risk is too high with complete breakthrough technologies. If it works, it's great. If it doesn't, it can be devastating to the community and the consulting engineer. By comparison, the incremental method does not deviate radically from proven technologies. Therefore, the chances of failure are minimized. If the incremental innovation process fails at some point, only one aspect of the treatment fails and a repair is more reasonable. Daigger would like to see future EPA incentives for innovation provide specific support for this approach. His experience, however, was that incremental innovations rarely qualified for I/A funding.

In the United States (and probably in most developed countries), scientists and venture capitalists are mainly interested in breakthrough innovations. Funding for research and development from the government, academia, foundations and private investors is more likely to support a brand new technology since the potential benefit (and therefore, the financial gain) is significantly higher, assuming it is successful. Daigger believes,

however, that this attitude needs to be addressed by the EPA. Both breakthrough innovations *and* incremental innovations should be supported. Breakthrough technologies are important; R&D funding should continue to support them. However, incremental innovations should also be encouraged and equally supported. This approach would reduce the risk of complete failure by offering a more conservative avenue by which to reach the ultimate goal of improved efficiency through major changes in wastewater treatment.

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Glenn Daigger, Ph.D., Department Head of Environmental Systems Engineering, Clemson University, SC. (803) 656-3276.

A constructed wetland expert describes "perceived" barriers to innovative technologies: Sherwood Reed

Sherwood (Woody) Reed is a prolific author and expert on the use of natural treatment systems for wastewater. He has produced college texts, chapters for EPA manuals, and a series of articles on this topic. Reed is frequently called upon as a consultant for constructed wetland projects for wastewater treatment and has served as an advisor for wetland projects with the Ministry of the Environment in Ontario, for the village of Minoa, NY and currently, for Niagara-on-the-Lake, in Ontario, Canada. In the early 1990's, Reed served as an advisor for the Solar Aquatics™ (or living machine) system which was designed as a pilot project at the Ben & Jerry's factory in Vermont. (Solar Aquatics™ is discussed as one case study in this report.)

According to Reed, the main barriers to the application of innovative natural systems for wastewater treatment are primarily artificial. Regulators, permit writers and even engineers demonstrate a clear "lack of familiarity" with these technologies as compared to the more conventional, well-established treatment processes. Reed notes that it is very difficult to be the first within a state to obtain the necessary approval and state discharge permits for any new technology. He sees resistance to change as being very strong.

Reed described this "provincialism" as something he experienced repeatedly. For example, in 1992, a community in the state of Delaware was interested in a constructed wetland system for wastewater treatment. Delaware had not yet permitted a single constructed wetland for this purpose. Reed was called in as a consultant. When the state regulators asked for verifiable data to support the technology, Reed suggested a site in Maryland, only 40 to 50 miles away. This site could have demonstrated a good quality constructed wetland which was functioning well (it was also one which Reed did not design, eliminating his personal bias). However, the Delaware state regulators expressed concern, since the site was not within *their* state borders. How could they be assured it would work in Delaware? Could they trust the data collected by another state? Reed believes that data-sharing and trust for that data must exist if we are to move forward with cost-effective solutions for wastewater treatment which use innovative technologies.

> "If this concern expressed by the state regulators is based on climatic differences, it is a valid one," stated Reed. "For example, if I were to try to sell a system that had only been proven in southern Florida to a community in Massachusetts, they *should* be concerned. But there are probably four to five hundred wetland systems in the

> U.S. and another ten or twelve in western Canada. We have lots of data to prove the capabilities of wetland technology."

A similar ordeal was experienced by the engineers at Clough-Harbour and Associates for the Village of Minoa, located in upstate New York. In the case of Minoa, a full scale wetland treatment system was permitted and has been under construction since the fall of 1994. Yet, prior to being permitted, Reed and the engineers at Clough-Harbour needed to spend a great deal of time (and therefore, money) with New York regulatory representatives to educate them about the use and effectiveness of artificial wetlands for wastewater treatment and to convince them of the technology's long term reliability. Both climate and odor concerns had to be addressed in the design of the wetlands.

The village of Minoa did receive some funding support from the New York State Revolving Fund (SRF) program for their selection of an innovative technology. The state legislature authorized a zero percent interest loan for the project. Reed is sure that the attractive loan was the driving force in Minoa's decision to try the innovative wetland approach. (Additional funding was provided on a cost-sharing basis with several other organizations). However, in general, Reed feels that the lack of funding for innovative technologies is generally not a barrier.

> "Part of the barrier to using innovative technologies is not just the reluctance of the regulators and permit writers, but also the consulting engineers. Engineers are reluctant to recommend a technology with which they are unfamiliar, that might in any way jeopardize their careers, their reputations, or their company. They do not want to assume liability for a system which has an opportunity to fail," stated Reed. "Also, it has to do with the fee structure, which might be based on a percentage of the overall costs of the treatment plant. And constructed wetlands are lower cost, simpler technology."

These comments were similarly discussed in the GAO Report to Congress (1994). Engineers have no incentive to pursue innovative technologies which might result in a much lower fee, if the standard and accepted fees in that state are based on a percentage of the overall costs. Many innovative technologies are far less costly than are more conventional, mechanical ones. Reed suggests the EPA support a legislative correction which would standardize engineers' fees on some sort of flat scale, such as by the millions of gallons of water treated per day. Such a fee structure would eliminate the bias of engineers to push communities toward the more familiar conventional technologies.

However, it should be pointed out here that several later interviews refuted this concept: engineers' fees are generally based on a flat rate, usually accounting for the amount of time required to complete a project. This differing perception is probably based on much earlier fee structures, practiced up through about the 60's and early 70's. Yet it demonstrates quite well that there are differing perceptions in the field that actively work to dictate the degree to which certain technologies are promoted, explored and recommended (Greatest Professional Interest (GPI)).

The village of Minoa illustrates this very bias of engineers toward conventional technologies. In response to a bid for services, twelve consulting firms responded. Only one, Clough-Harbour, proposed a non-conventional and simple solution to Minoa's problems that could provide dramatic cost-savings to the village.

Another barrier comes into play when a community focuses solely on the cost of a treatment system's construction and does not take into consideration the 20-year life cycle of that system, which incorporates the operations and maintenance (o & m) costs. Reed notes that some engineers will stress possible savings with a conventional system's construction cost without properly discussing the o & m costs. Reed stated:

> "While it is true that some innovative technologies may cost more to construct, particularly if large amounts of land must be purchased as is common with natural treatment systems, the overall cost to the community should take into consideration the savings in operations & maintenance over the life cycle of the plant. Unfortunately, small communities are making decisions without first seeking enough guidance from an EPA or a state regulator, due to staffing constraints within government offices. Perhaps EPA could require the consulting engineers to itemize for the communities the comparative costs for o & m over the 20 year life cycle of a plant."

Under Reed's plan, penalties would be levied against engineers who did not properly represent the entire cost of a wastewater facility to show the lowest possible life cycle cost rather than just the construction cost. The cost of construction alone should not determine the community's decision for the selection of a wastewater treatment system.

Some of the barriers discussed above can be attributed to the lack of support for technology transfer as stated earlier. The universities which train our engineers also need to incorporate new courses into their programs to teach students about alternative and innovative wastewater systems. At the graduate level, Reed has noticed some changes, with courses being offered in the ecology of wastewater and natural treatment systems. Reed's most recent publication, *Natural Systems for Waste Management and Treatment*, has just been updated and is being used in at least four engineering programs across the nation.

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Sherwood (Woody) Reed, P.E. EEC, Inc., Norwich, VT. (802) 649-1230.

A Consulting Firm's Difficulties in introducing innovations to the public sector in the U.S.: Susan Peterson

Truly innovative technologies are, by definition, new and unproven; therefore, they are inherently risky undertakings. Product developers and patent holders of innovative wastewater treatment systems and processes may find inroads into the marketplace more readily accessible in the private sector or in foreign countries.

Innovators may find private firms rather than public entities more willing and more able to serve as a demonstration site for new technologies. Ben and Jerry's Homemade, Inc. of Waterbury, Vermont provides a good example. As a "green" corporation, Ben and Jerry's served as a demonstration site for the experimental Solar Aquatics system. Solar Aquatics uses a complex of biological organisms which are placed in a series of translucent tanks under a greenhouse. This artificially created wetland is used to treat wastewater through natural processes. Susan Peterson, president of Ecological Engineering Associates (EEA) which owns the patent and markets the Solar Aquatics system, found that *private* firms are much easier to work with, as compared to *public* facilities. Peterson said "private companies are better able to state their problem clearly and succinctly. They can describe their current wastewater system and they know how they'd like it to be fixed. They also have a clearer idea of how much money they are willing or able to spend." In contrast, Peterson's experience with municipalities often shows that publicly-owned treatment works (POTW's) are not as well able to articulate what they want or need. There is confusion over the regulations and requirements and a lack of training and knowledge of standard wastewater treatment processes. Moreover, the financing is typically very murky. The mindset, always, is "spend as little as you can."

An innovator’s accessibility to the private sector can be attributed at least in part to perception by regulators and permit writers. According to Diane Perley, engineer with the Environmental Facilities Corporation's "Self-Help Support" section, regulators in New York tend to be particularly conservative with small municipalities because they cannot afford a replacement system. This pattern is accentuated in Regions where failed technologies were experienced during the Innovative/Alternative incentive grant program of the 70's and 80's. "A private, for-profit corporation, like a MacDonald's Restaurant, may be more open to trying a theoretically cost-saving treatment technology, and the regulators are more open to allowing it. If the system fails, the for-profits know they will have to replace it and the permit writers know they will find the cash needed to do so. Municipalities don't have that advantage."

Peterson has also found much quicker acceptance of the Solar Aquatics system in foreign countries. In the Province of Ontario, Canada, Peterson presented the benefits of EEA's patented Solar Aquatics system in 1994. The regulators with Environment Canada were very receptive (and, according to Peterson, actually excited) about Peterson's proposal. After just nine months following Peterson's initial presentation, the process was approved and a contract with EEA was signed. A Solar Aquatics treatment system will be built in Nova Scotia during 1995. "In the U.S.," Peterson stated, "that same approval process commonly takes two years, and that's considered good. It's not uncommon for an approval to take six years." EEA's experience in obtaining authorization in the state of Massachusetts (discussed later) details this problem. Additionally, despite having collected verifiable data under a tightly controlled pilot study at Harwich, Massachusetts, and finally obtaining permits in that conservative state, Peterson anticipates EEA will be required to repeat the entire process for approval in any other state in which she markets. This concern was repeated in a separate conversation with Michael Giggey, Sanitary Engineer with Wright-Pierce Engineering (the firm involved in the reviewing process for the Solar Aquatics system): "The cost of a demonstration project of this magnitude is insurmountable for most entrepreneurs, at $2.5 million in Massachusetts alone," stated Giggey. "One validated demonstration project with such a huge investment, it seems, should suffice for approval in other ecologically similar states." But our findings were that it doesn't; states often do not trust the data from other states, regardless of climatological and geographical similarity.

Congress and the EPA have identified this important barrier to innovative technology. Ocean Arcs International, the "think tank" research institute that originally designed the Solar Aquatics technology, is currently working closely as a contractor with the Massachusetts Foundation for Excellence in Marine and Polymer Science (MFEMPS) which has received substantial grant funding from EPA as a result of $5.75 million Congressional add-ons during FY '92-95 to demonstrate non-proprietary designs using natural treatment systems called "Living Machines". These are located at four separate sites in four different states around the country: Maryland, California, Massachusetts and Vermont. Each demonstration site will test a different application of the second generation Solar Aquatics technology.

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Beth Josephson, Associate Director, Ocean Arcs Institute, Inc. (508) 540-6801.

Michael Giggey, Sanitary Engineer, Wright-Pierce Engineers, Topsham, ME. (207) 725-8721.

Diane Perley, Engineer, Self-Help Support Section, Environmental Facilities Corp. Albany, NY. (518) 457-3833.

Susan Peterson, President, Ecological Engineering Associates, Marion, MA. (508) 748-3224.

Head of Non-Profit Foundation Advocating Wastewater Research believes that Innovative technology programs need to be more efficiently managed and better funded: Glenn Reinhardt

Glenn Reinhardt is the Executive Director of the Water Environment Research Foundation (WERF), a group is heavily involved in research efforts to advance science and technology for the benefit of the water quality profession and its customers. WERF manages research programs, coordinating the needs and interests of various stakeholders through a consortium of volunteers, from utilities, academia, consulting firms, government and industry. (The WERF program is discussed in greater detail later in this report). As Executive Director of these research efforts which support and substantiate many innovative technologies for wastewater treatment, Reinhardt has a unique and unequaled viewpoint on effective incentives and barriers to innovation. Working closely with the industry and with EPA, he is in a position to voice the concerns and frustrations of his constituents along with some insightful ideas for solving some of these concerns.

One barrier Reinhardt identified is the current bidding process. The largest U.S. municipalities must continually battle the problems of dealing with the tremendous (and always growing) demand for wastewater treatment, and the need for increasing capacities. Innovative, cost-effective methods of treatment which have the capacity to offer potential for quick pay-back are of high interest for these municipalities. There are many examples of innovative processes or systems that were piloted at large municipalities, such as in New York City and Chicago. The County Sanitation Districts of Los Angeles provide one such specific example. However, Reinhardt finds it more difficult for a municipality to accept proprietary equipment today as compared to years ago, due to changes in the required bidding process.

Edward Wagner is the Deputy Commissioner of the New York City Department of Environmental Protection and has a great deal of experience with cutting-edge technologies. According to Reinhardt, "Wagner has told me that there was a time when equipment suppliers were able to make enough of a profit margin that they could partner with a POTW, like New York City, to try out new technologies, perform research and collect data. Many technologies got their start that way. But now, because of the low-bid process, the City cannot accept proprietary equipment, and the manufacturers do not have the profits to invest in R&D. With no flexibility built in, nobody is willing or able to afford the risk." Wagner has become a strong proponent of the WERF research programs since he is unable to procure that level of research support on his own.

Reinhardt generally supports the current State Revolving Fund (SRF) which provides low-interest loans and other forms of assistance, but not grants, to municipalities; and which gives the states the flexibility to give as low as zero interest loans and other forms of assistance to municipalities using innovative technologies. He is aware of problems with the earlier Construction Grant program, which offered additional financial incentives to promote innovative or alternative technologies. For example, the Northeast Ohio Sewer District was unable to meet its NPDES permit and, according to Reinhardt, was urged by the EPA to try an innovative activated carbon system. The system never worked right, and the end results were fines and punitive action against the sewer district. A great deal of data were collected and attempts to correct the problems were made**.** However, after fifteen years, the plant is still not working right. The entire system needs replacement. "The battle began over who would have to pay for this replacement," stated Reinhardt. "Initially, the District planned to sue everyone." Modification/Replacement funds, which were an important part of the I/A program, were not made available to alleviate the situation. The case was eventually settled with the appropriation of funds from the Ohio state legislature.

When asked more specifically about the State Revolving Fund program, Reinhardt stated that if legislative support continues, he would like to see the loan program evolve into one that is two-thirds SRF funding and one-third grant funding. "The larger cities say they don't like the revolving fund program," Reinhardt stated. "They want the government to *underwrite* the expense, not give them a loan. However, given today's economic situation, bonds may be more effective in ensuring that *appropriate choices* are made for treatment plants. Low interest bonds are particularly good for the smaller to medium sized cities."

Reinhardt noted that a huge amount of money is still needed by wastewater treatment facilities to meet the Clean Water Act requirements. Citing an April 4, 1995 Water Environment Federation (WEF) press release, "At least $2 billion in continued federal funding is needed for the State Revolving Fund capitalization program in FY 1996. Large funding needs include secondary treatment facilities, minimum combined sewer overflow control, and water quality permitting." A bar graph in the press release clearly indicates the drastic decrease in nationwide funding for wastewater facilities. In 1973, wastewater funding was $5.2 billion, or 2.2% of the federal budget. In 1995, that amount is $1.5 billion, or 0.2% of the federal budget. WEF supports an appropriation of at least $2 billion for the SRF capitalization program in FY 1996.

In order for innovative technologies to be successful and commercially available, they

must first be understood and accepted by industry and by the community. "*Marketing* some of these new products is a critical barrier to many new technologies," stated Reinhardt. "We saw it when ultra-violet first came out, and now we really see it with biosolids. Marketing can take millions of dollars, particularly when the issue is controversial and public acceptance is required, such as with biosolids reuse programs," added Reinhardt. "This is where the research done by WERF is invaluable. The kinds of objective analysis WERF does supports all the stakeholders with the data they need." Marketing is carried out through Water Environment Federation publications in the form of brochures and bill stuffers which can be distributed in mass, as well as through a series of educational videos and books which could be used in public meetings. Examples of biosolids promotional materials include *"Biosolids Recycling: Beneficial Technology for a Better Environment"*, (a bill stuffer), "*Biosolids Recycling Public Awareness Program"* (a 12 minute video with fact sheets and brochures) and the *"Biosolids Information Kit*".

When asked what EPA could do to improve the NPDES program to support innovative technologies assuming no additional money was available, Reinhardt stated that he would simply like EPA to improve the regulated community's access to information and technically knowledgeable staff, possibly through electronic bulletin boards, the Internet and Email. He would also like EPA to be 'more forgiving.' "Permit writers and enforcement staff need to be willing to take more heat when innovative technologies don't work," Reinhardt suggested. "The EPA could work through their own regulatory process to change the Clean Water Act, removing some of the barriers to innovative technology, so that large municipalities would be more willing to try them out. The environmentalists will also have to be more forgiving. They have to realize that unless we take some risks and try better treatment systems, in the long run, we'll all end up with a dirtier world." Quoting from Tom Peters book on Total Quality Management, Reinhardt added "No one ever did anything that was *truly* new or innovative right the first time."

Reinhardt would like EPA to consider watershed issues and water quality problems, with reclassification designations done through a series of negotiations based on cooperation and idea sharing. Of great concern is the growing number of mandates passed on to municipalities by Congress with what some view as inappropriate regulations that are not supported by current or accurate scientific research. These mandates could act to form barriers to innovation. They might, of course, also act to provide visionaries with incentives to design new techniques resulting from regulatory-driven mandates.

Reinhardt feels EPA needs to become more efficient in making decisions. "The process

the Office of Water goes through in order to perform research needs to be revamped in its prioritization process. Even under the Environmental Technology Initiative (ETI), Reinhardt feels too much time is spent haggling over details and decisions. "My impression is that money is available, but it's earmarked money which enables EPA to meet regulatory deadlines and court orders."

Other programs that need to increase efficiency, according to Reinhardt, include EPA's Office of Research & Development (ORD) and the National Academy of Sciences. The ORD needs to reorder priorities with a customer focus and sponsor research that is directly applicable to real problems. Reinhardt cites a successful program sponsored under the auspices of ORD/Risk Reduction Engineering Laboratory, called the Taft Center, in Cincinnati, OH. The Taft Center oversaw pilot plants and fellowship programs which were supervised by senior professors in academia, thus educating graduate students to become experts in specialized fields of wastewater treatment. This program has produced some of our country's expertise today in primary and secondary trickling filters and in sludge processing.

The National Academy of Sciences also sponsors interesting research, with a budget of $345 million. Reinhardt feels this group needs to network and form partnerships with other "major players" so that their research sponsorships are targeted toward *applied* rather than basic research. Global warming is an example of such an issue the Academy has pursued in depth.

Research programs like those mentioned above, or similar to the partnership program of WERF, are dependent upon outside funding in order to promote innovative technologies. Risks for *all* stakeholders can potentially be lessened with more objective and validated research, which truly "serves the customer." Public-private partnership forces the same level of efficiency into the public realm as found in private businesses. Funding for WERF's research program has come in part from EPA via Congressional add-ons. Reinhardt is concerned about the continued long-term government support for R&D, and suggests that the significant amount of money allocated for the State Revolving Fund be used to build up a resource base for R&D. If, for example, one percent of the money loaned could be mandated as a set-aside for R&D programs, in twenty years the "pot" would be substantial, and the investment would pay for itself.

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3. Analysis of the Regulatory Process

Discharge permits for wastewater are regulated mainly through the NPDES program at the federal or state level for fully delegated states. The permitting process and the job of the permit writer have become increasingly more complex as new regulations are added and as manufacturing processes evolve to support new product lines, potentially creating new categories of discharges. Industries, permit writers and municipalities alike must closely monitor all new discharges, incorporating pollution prevention techniques and process modifications wherever possible to reduce these discharges.

This regulatory process, meant to target "polluters", creates important barriers to those who wish to try innovative technologies. These barriers are discussed in the case studies, critical incidents and viewpoints which follow.

Understanding the NPDES permit process; case study

Does the NPDES permit process encourage or discourage innovative treatment technologies? Technically, the technology used to meet the effluent guidelines is outside of the permit process. Gerald Potamis, Chief, Wastewater Management Section of EPA New England Region stated "It is EPA's job to permit the *effluent*; EPA is not in the business of permitting technology. We don't care how they get there, as long as they are able to meet the end-of-pipe limits." Providing permits for permittees using an innovative technology might be misconstrued as acceptance or endorsement, which could be cause for a lawsuit should the permittee's innovative technology fail. When innovative technologies do fail, Thomas Lang, Environmental Engineer II in New York state, stated that the first thing a municipality will try to do is blame the state for "approving" their system. "They perceive that the Department of Environmental Conservation approved the process or technology because we gave them a discharge permit, and they want us to 'fix it'." Diane Perley, engineer with the Environmental Facilities Corporation's "Self-Help Support" section, added "In the end, it's the permittee that is usually left holding the bag. We cannot help them." It is the role of the permit writer to approve the discharge, not the technology itself.

It might be assumed then, that the NPDES permit process has no real influence on permittee decisions to try innovative technology. However, this assumption is not accurate. Consider the rigid statutory limitations, particularly the three year time limitation

and the validity of the effluent guidelines, many of which are based on outdated data. The permit writers themselves vary tremendously in terms of their technical expertise, training and experience with new technologies. An applicant who approaches EPA with a proposal for an innovative technology for wastewater treatment is told "Sure, you can try it. If it doesn't work, or if doesn't work well enough, you will still be required to be in compliance within five years of your application date. And if you cannot meet the effluent limits, you *will* be penalized." The fines are considerable, at a maximum of $25,000 per day, should the innovation fail to perform within the schedule. Even if a permit writer grants an extension or chooses not to enforce a compliance schedule in an attempt to support an innovative project, a citizen lawsuit could force compliance and create an overwhelming negative publicity campaign. "The larger industries have a higher liability," stated Kimberly Hankins, a past employee of the EPA Headquarters Permits Division, "Citizens notice the larger corporations more, they are perceived to have deep pockets, and after all, it's really hard to sue a municipality." Moreover, it is unlikely that insurance is available to replace failed innovative technologies, although some states, such as Pennsylvania, require that a bond be posted for public projects by the consulting engineer or inventor to cover the cost of replacement should the system fail. This creates a financial disincentive for the inventor, but an incentive for the user of that technology.

The limitation of time extensions within the NPDES program is the most frequently cited barrier to the application of innovative technologies. Yet, even within the water quality profession, there is disagreement over how much time should be allotted for a new technology to reach compliance. Industry, inventors and entrepreneurs tell us that six years is sufficient to carry out performance of the research, collection of data and "getting the bugs" worked out of an innovative system so that it will meet EPA effluent guidelines. Many of our case studies and critical incidents demonstrate this. But not all regulators agree on the "reasonable" time limits. For example, one EPA representative felt that the provision of a time extension assumes that the bulk of research and development has already been completed and that extensions are required in order to only "tweak" the system to meet the compliance schedule. He felt that six months to one year extension was adequate. Robert Kuehn, project manager of a wetlands proposal for Shell Oil Corporation, felt this short time extension was unfeasible. "It would take at least six months just to get the funding approved in a company as large as Shell." he stated. The question really lies in defining when the clock starts ticking on the time extension.

A comprehensive analysis of the NPDES permit itself in order to determine barriers and incentives within the permitting process is extremely complex and is beyond the scope of

this research. However, several experienced permit writers at the federal and state levels conveyed pertinent information which strengthens the statements made elsewhere in this report. Their comments are summarized below. Three permit writers from New York state were interviewed in person. Likewise, representatives from private industry and academia described some barriers they perceive within the permitting process.

First, a brief overview of the permit process is in order. This overview is summarized from EPA's Training Manual for NPDES Permit Writers, published March 1993. This manual is currently being revised/updated to include new developments in the NPDES program such as in Whole Effluent Toxicity (WET).

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In 1972, Congress enacted the Clean Water Act, giving EPA the challenging job of setting the effluent guidelines for industries and municipalities. Statutory requirements promulgated by EPA set *technology-based* effluent limitations on an industry-by-industry basis. Major industries were categorized for pollutant discharge limitations using Standard Industrial Classification (SIC) codes. Each industrial category must follow nationwide limits, so that a chemical manufacturer in Oregon, for example, will have the same effluent limitations per production unit as a chemical manufacturer in Maine.

The technology-based effluent limits allow many permits to be handled today as routine administrative procedures. Each published guideline has already been litigated in the courts; lawsuits contesting the standard have been settled. Many permit writers prefer this "no-dickering" procedure with no flexibility allowing for discussions or negotiations over the applicant's effluent limits. In some industrial categories, however, the rigidity is a definite barrier for permit writers. Brad Mahanes, for example, an Environmental Scientist and a past employee within EPA's Office of Wastewater Management, Permits Division, found that his work with the pulp and paper industry was substantively confined when considering innovative technologies vis a vis the effluent guidelines. These guidelines are currently undergoing revisions because the older regulations may not account for major changes in paper manufacturing over the last ten years and there is increased concern over dioxins and furans, byproducts of this industry. In contrast, Mahanes' colleague, Steve Geil, who specializes in inorganic chemical industries, cites the more recently developed guidelines for this industrial sector. He feels the guidelines are based on solid

data and accurately represent treatment capabilities within this industry. The system enables permit writers to process permits without getting bogged down in litigation issues. Innovative technologies may be used to meet the technology-based effluent limitations. "Unfortunately, updates to the categorical effluent guidelines, such as the one for pulp and paper, seem to only be done when EPA is facing a court order," stated Ed Riley, permit writer for New York state. "Some environmental group sues and the court orders EPA to provide new rules. The Agency is trying to streamline the post-litigation possibilities by involving stakeholders in a negotiated rule-making process, called "reg-neg". I understand they got 13,000 pages of comments on their first draft." added Riley, holding up the original six inch thick briefing document. Responding to the comments will be a huge undertaking, but, according to Riley, those responses are needed.

Existing industries that discharge directly into a body of water (vs. indirectly through a municipal treatment plant) are required to follow "Best Control Technology" (or BCT) for the five conventional pollutants: Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), fecal coliform, pH and oil & gas. The toxic pollutants (126 "priority" pollutants) require application of "Best Available Technology" (BAT) which is economically achievable. These standards are developed by EPA for each industry through ongoing research. Existing industries are given three years beyond the effective date of a new standard to come into compliance through retrofitting. New industrial direct discharge sources are required to meet existing standards as they come online and it is expected that they will have the advantage of installing state-of-the-art treatment technology.

The permit writer must also consider *water quality-based* effluent limitations. A water quality-based limit is designed to protect the water quality of a receiving body of water by ensuring that state water quality standards are met. Through the water quality based limits, states determine the classification of a receiving body of water and its value and use for public water supplies in propagation of fish and wildlife, recreation, navigation and industrial purposes. An anti-degradation policy requires states to maintain the quality of high quality waters and outstanding natural resources. States review their water quality standards and revise them at least once every three years, if necessary. In addition, states may adopt zoning variances or low flow exemptions which affect the application and implementation of the water quality based permit limits. EPA retains the authority to review and approve these policies.

The permit writer is then obligated to assign discharge limits based on the more stringent of the two programs (technology vs. water quality-based). Compliance deadlines are

statutory requirements and cannot be extended without an Administrative Order.

When no performance standard or effluent guideline exists for a particular industrial category or for a particular pollutant, the permit writer is required to use *"Best Professional Judgment"* or BPJ. BPJ is defined as "the highest quality technical opinion developed by a permit writer after consideration of all reasonable available pertinent data or information that forms the basis for the terms and conditions of an NPDES permit." (U.S. EPA; 1993, p. 4-12). Unique factors relating to the applicant can also be considered. The effluent guidelines which become designated under BPJ are subject to the Anti-backsliding Regulation, which prevents easing up of effluent limitations in the future. This may increase the risk for some sites considering state-of-the-art technology, which claims to "do more than is mandated for less", because the regulation does not encourage cleanup beyond the mandated limit.

Best Professional Judgment offers permit writers some flexibility. It can also result in inequitable permit decisions when comparisons are made within and among states. Diane Perley, an engineer in New York, notes that one permit writer in the Adirondack region of New York was "burned" too many times by the use innovative technologies under the Innovative/Alternative program that failed and left small communities with no system. Therefore, Perley has learned to take a conservative approach. Thus, although New York state is known to be more progressive in supporting new technologies, innovation will have a difficult time winning acceptance in New York's Adirondack region.

Permit writers may at times find themselves influenced by the local political climate. If conservative, it may discourage the application of technologies that are not solidly proven, as in New York's Adirondack Region, or if progressive, seek opportunities to try new technologies. As noted in interviews and focus group discussions for this project, equally important is the permit writers' training, experience and level of education. Requirements for this entry level position may vary substantially among delegated states. All EPA permit writers must minimally have a four-year degree in science, but some participants noted that an engineering background is not necessarily required. This is also true in New York state. And, according to Ed McHam, an experienced EPA permit writer in EPA's Region 6, "the permit writer could have a biology degree; they really do not have to be a trained engineer. EPA permit writers are provided a week-long training program to give them the basics. What's more important is their ability to communicate effectively with the industrial representatives with whom they work." New York state permit writers have no formal training program, and instead are initially supervised closely to assure their understanding.

"They have the "Technical Operational Guidance" series (or TOGS) to guide them," stated Thomas Lang, Environmental Engineer 2. "Unfortunately, the TOG for BPJ is very old and really needs to be redone."

A great deal of on-the-job decisions require BPJ, as well as a clear knowledge of the specific industrial processes being permitted so that samples provided by the industry or municipality are taken at appropriate locations throughout the process line. EPA's *Training Manual for NPDES Permit Writers* (1993) states:

> BPJ has proven to be a valuable tool for NPDES permit writers over the years. Because it is so broad in scope, BPJ allows the permit writer considerable flexibility in establishing permit terms and conditions. Inherent in this flexibility, however, is the burden on the permit writer to show that his/her BPJ is based on sound engineering analysis."

Since the BPJ is subject to litigation from both the applicant and the environmental community, who may perceive it to be too lax, the permit writer must research and clearly document the basis for his or her decision. These "fact sheets" are what set some more experienced permit writers apart from others. They can allow exemptions with the proper documentation which detail the industrial processes and show how the limits will be met. Barriers to innovative technologies most often arise from a lack of credible data provided by the applicant which the permit writer requires to justify the claims for a Best Professional Judgment decision.

The first focus group meeting for this project was held on March 16, 1995, and attended exclusively by EPA staff, with representatives from the Permits Division within the Office of Wastewater Management. The level of permit writers' experience was discussed as a potential bottleneck to users of innovative technologies. The slow processing of permits which utilize unfamiliar technologies by inexperienced and/or conservative permit writers may be an important barrier to a community's decision on whether to explore innovative technologies. Continued education for permit writers to learn of and about the latest technologies as well as workshops in industrial engineering should be an ongoing requirement**.** One EPA permit writer noted that in most states and in the federal offices, the Permits Division and the Technical Support Division are usually separate offices.

Applicants which require a BPJ decision may find themselves working with an overloaded and under-staffed permit writing unit. Thus, applications which include the use of

innovative technologies may be denied solely because of the workload a BPJ case requires. An interesting suggestion made by James Lund, EPA's Director of Industrial Pollution Prevention program, is to provide *incentives* to permit writers by rewarding them (rather than penalizing them) for the number of the flexible permits they can get through in a year. For EPA or state permit writers, the "exceptions" process needs to become more normalized to preclude confrontation regarding a BPJ case. One example where the incentive approach works well is the 3M Corporation in advocating a company-wide pollution prevention program. The program, according to Thomas Zosel, Manager of Environmental Initiatives at 3M, is taken very seriously by top management with employees being given high-level awards for their contributions. These incentives, which are sometimes monetary, work extremely well. 3M has saved $750 million since the program's inception in 1972, and achieved a 27% reduction in waste.

A permit writer's viewpoint on barriers within the NPDES permit

Nicholas Prodeny is an experienced permit writer in EPA's New England Region. When asked to describe barriers he has observed with the NPDES permit process for wastewater treatment, Prodeny replied, "Each industry is looked at on a case-by-case basis. Usually, there are not enough data from the applicant or there is not sufficient documentation to support toxicity limits for a new pollutant. A lot has to be discussed and negotiated." The goal, Prodeny noted, is to reach an equitable draft permit that will be accepted by both the regulators and the environmental advocates.

Prodeny had an opportunity to assist in a recent permit modification for Pfizer, Inc., one of the largest pharmaceutical manufacturers in the U.S. The manufacturing site is located in the state of Connecticut, which has an approved state-level discharge program. Because of the complexities involved, Prodeny's expertise was welcomed and appreciated. During the site visitation, Prodeny explained the layout. "It is a maze of individual processes, each with their own wastewater stream. The manufacturing has evolved from the 1950s. Many new products have been added, others perhaps eliminated. Pfizer makes lots of different products, from vitamin C to all kinds of antibiotics. In the end, however, each process empties its wastewater into the same equalizing pond for treatment." Not only must the permit writer look at each of these processes individually, but he or she must also investigate possible side reactions which could occur in the equalizing pond. Minor changes from the chemist's perspective in any of the processes needs to be evaluated in terms of the overall system. Adding a catalyst to speed up a chemical reaction, for

example, might result in an unknown byproduct. In this situation, industry evolved for the purpose of production, without a design for water pollution control or prevention. The permit writers have the task of sorting through the possible chemical interactions, and without much hard data to go by. Considering unproven or unknown technologies when the task at hand is already difficult tends to add another layer of difficulty.

Prodeny has also worked a great deal with the major power plants, such as Sea Brook. These plants were built with state-of-the-art pollution prevention and pollution control technologies. Permits, by law, are reissued every five years. The system was designed to collect and report data in anticipation of the required permits on a monthly, bi-monthly and annual basis. This creates an enormous amount of data upon which to stay on top. Prodeny would prefer a system which only collects the necessary data, and compiles or summarizes it through an appropriate analytical method. In this respect, innovative technologies which were applied are reducing the permit writer's efficiency by collecting too much raw data and not compiling it in a useful way.

Prodeny described another concern with the NPDES permit system, which is not isolated to innovative technologies, but is a serious gap nonetheless. The permittee may use the permit as a "shield." It is assumed that the applicant will report to EPA all the pollutants in its waste stream. (This, of course, assumes that all pollutants are known, which may not be true.) However, industries are not required to report their unpermitted chemicals, even though they may be dangerous or suspected carcinogens. Prodeny would, therefore, also like to eliminate the categorical pollutants listing. This is the list of commonly created pollutants for a given industry category within a SIC code. "It's just not appropriate for all industries, "explained Prodeny. "I'll give you an example. The organic chemical industry is required to monitor for 56 chemicals, even if a particular industry does not even use them in their processing. It's a tremendous cost burden to the industry. There is a tremendous amount of variation of chemicals used within this industry. And on the other hand, they are not required to monitor the hazardous chemicals that they *do* have if they are not on the list. It's very difficult to justify some permits."

The training for permit writers seems adequate,according to Prodeny. It consists of an intensive four or five day training, including roundtable discussions,conducted by EPA Headquarters Office of Wastewater Management (OWM), Permit Division. The issue of how to treat innovative technologies within the context of an NPDES permit always arises at these these training courses. The instructors **always** stress that the NPDES regulations (and therefore the federal or State permit writer) does not prescribe the

technology to be used by the permittee; the permit writer is only concerned with the permittee meeting the limit. On the last day, a straightforward multiple choice exam is given. In order to pass, the trainee must get a score of 80 to 85%. "I think it's pretty fair," stated Prodeny. "An engineer probably will have the best background for this job, but it is not required. A biologist can take the exam as well, and do just fine." Nevertheless, the job of the permit writer can be difficult. "Each industrial permit is unique and requires knowledge of that industrial operation, processes, end products, appearances of waste and knowledge of how the wastewater is treated," stated Prodeny. Add to that the complications of proposals for unproven, innovative technologies, and you can really find barriers resulting from under-experienced and overloaded NPDES permits division staff.

Experiences with a strict State discharge permitting system; critical incident

The state of Pennsylvania has a stringent discharge permit. Westfield, one of the northernmost towns in Pennsylvania, is located in the central portion of the state in Tioga County. This small town had a serious wastewater contamination problem, due in part to the wastes generated from a tannery within the town. During certain times of the year, the tannery released a "chemical soup" with extremely high BOD as well as other toxins. During the mid-1980s, Westfield's existing primary sewage treatment plant was required to come into compliance with secondary treatment. The situation was complicated by the large amount of extraneous influent water flowing into the aging plant through the original sewage lines, resulting in unpredictable side effects.

The town selected an innovative wastewater treatment technology because of its claim to be "easy to operate." *If* the system worked correctly, it should have also been quite cost effective. However, the system has been in operation for several years and it has *not* been able to meet effluent limitations for nitrogen during certain times of the year. Corrective action has been going on for five to eight years. Also, the original engineering firm went bankrupt, and a new engineering consultant had to take over.

This case provides an example of the regulatory barriers which exist within the state of Pennsylvania's discharge permit system, and also how one permit writer used some flexibility inherent in the regulations to allow the town of Westfield to be in compliance.

The technology chosen was a *"submerged fixed film reactor"* and was produced originally by only one manufacturer. This is a technology that was designed and successfully used on ships, where the ebb and flow of the ship caused by ocean waves created enough

mixing for the biological breakdown of waste within the system. It has been used successfully with municipal sewage plants in the south, but has not been as successful in the colder climates where the nitrogen fixing bacteria are affected by cold temperatures and long winters.

In Pennsylvania, a fairly rigid policy for setting effluent guidelines exists for each receiving stream, based partly on the stream's temperature and pH. These guidelines allow for a seasonal variation, where the warmer seasons have more stringent effluent limitations for pollutants like ammonia than the winter months do. Winter is legally defined as November to April throughout the state, with no flexibility for the more northern communities nor those in a higher elevation.

The Westfield plant was unable to meet water quality based ammonia limits during May and June. It was determined that the temperature of wastewater coming into the plant was abnormally low, perhaps due to inflow of water leaking into the old sewer system. In fact, it was lower than usual in other nearby communities, so there seemed to be a localized natural pattern. However, once the water temperature increased during the summer, Westfield's system worked fine; effluent limitations were met.

The problem was studied over several years and a series of remedial activities were tried. The cost of this innovative system continued to escalate. Richard Adams, Chief Permit Writer assigned to this region, realized that the rigid permit system for Pennsylvania was the direct cause of Westfield being out of compliance.

> "Westfield was so close to meeting their effluent guidelines. I realized that if I could change the definition of "winter" to start in mid-September (rather than November) and end in mid-June (rather than April), all would be fine. And in fact, that is what eventually solved the problem."

Adams based this decision on his understanding of the treatment technology and remedial activities being tried by Westfield, and his knowledge of the local ecosystem. He felt that other permit writers might not have been willing to do this, but he decided to face this barrier with a relatively simple "common sense" solution. After six to eight years of work, Westfield may finally be in compliance during the summer of 1995.

Pennsylvania's "Experimental Permit" barrier

Pennsylvania's strict regulatory system results in other barriers, which are described by three Pennsylvania Department of Environmental Resources (PA DER) employees. The first is in regard to dischargers who select innovative technologies and are required to file for an *"Experimental Permit."* According to one PA DER employee, the "Experimental Permit" can be required for just about anything. This adds burdensome fees and insurance premiums, and can take up to nine months of additional negotiating time. In addition to extra insurance requirements, the manufacturer (or vendor) is required by law to post a bond to cover the cost of failure, in case the system doesn't work. Each attorney in the Westfield case discussed above sought to minimize the financial risk of the party it represented; nobody, of course, wants to be held liable regardless of why the system might fail. Since Westfield was unable to meet effluent limitations for so many years, the bond was extended each year and was transferred to the new consultants when the original consultants went bankrupt.

Other barriers in Pennsylvania

The state of Pennsylvania discourages innovative technologies in other ways. According to Dana Aunkst of the Division of Municipal Planning, communities that were not in compliance under the Innovative/Alternative program were placed on a priority list for grant funding. The priority list was based on the level of noncompliance, the impact on public health, impact on a stream, and on the community's financial need. In Pennsylvania, if an I/A project failed, the only way to obtain a modification/replacement grant was to get back on the priority list and be evaluated against all other projects. Since cleanup of the discharged wastewater would likely be at least partial with the innovative technology, the priority/need for the failed technology would lower the standing of the township on the list, making is nearly impossible to obtain further financial support. The risk was extremely high, particularly for small communities.

This priority system is still the basis of the funding decisions made today under the State Revolving Fund (SRF) program. Once the grants were phased out and replaced by the loan program, the financial incentive to risk a new technology was gone, and there has been very little interest in innovative systems.

Richard Adams, Chief Permit Writer in the Williamsport regional office, notes that consultants shy away from the use of constructed wetlands, lagoons and trickling filter

systems in Pennsylvania.

> "The Pennsylvania standards are very high, preventing innovations from being considered, " stated Adams. "In some other states, the rules according to 40 CFR which regulate a lagoon or trickling filter system have been relaxed somewhat, but not in Pennsylvania. A community must first try to meet the strict effluent limitations. They must carefully record data following the installation. Then if they can show that they cannot meet the effluent requirements of the permit, the consultant can apply for a relaxation of the rules *afterwards*, and request that new limits be set. Engineers won't touch this, because they want assurances up front."

Adams also described a problem with requirements for constructed wetland treatment. Even underneath the treatment site, the hydrological, geological and soils standards are required to match that of a *conventional* wastewater treatment plant. *All* constructed wetlands have to be lined, and all discharges must go to a defined stream when there are measurable releases. Adams stated that some other states are much less stringent as long as the consultant can show that nothing will migrate offsite.

It was felt that these strict Pennsylvania standards are meant to set guidelines for towns that choose not to hire a professional to guide them. The result is that there is no room for judgments, exceptions or relaxation of the guidelines set by the state.

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The 301(k) waiver program; case study

In 1991, EPA initiated the Industrial Pollution Prevention Project (IP3) as an agency-wide multi-media program with the objective of promoting pollution prevention through process changes rather than end-of-pipe pollution control. Pollution control in the United States has been carried out exclusively because of government intervention, with regulations setting limits on discharges based on best available technology (BAT). Pollution prevention through process change is the preferred option for reducing risk to the environment and to human health. These prevention methods can benefit industry by reducing production costs through lower waste disposal and energy costs, decreased liability concerns and increased efficiency. The industry's public image might also be enhanced if they become known as an environmentally friendly, "green" industry.

Under the 1977 Clean Water Act, Congress passed an amendment to encourage the use of innovative technologies for pollution prevention. The amendment included the "301(k) innovation waiver and pollution prevention" provision. This section of the amendment provided an opportunity for permit holders to request that compliance be extended for up to three years if they used an innovative technology to meet or exceed their BAT permit limits. The program was set up with good intentions; unfortunately, the program did not work. The problems with 301(k) were studied in a report by Kerr & Associates (date unknown), and are summarized below.

First, the 301(k) waiver had no provision for a "soft landing" for innovative technologies, which were used in good faith but narrowly missed their compliance schedule or effluent limitation. Second, the time extension of three years was found to be too short to fully implement a truly innovative technology. Third, some sections of the waiver provision were quite vague, leaving permit writers and permit holders uncertain about what could be categorized as an "innovative" technology, and determining at what point the compliance clock started ticking. Finally, regulatory uncertainty and political controversy regarding the waiver caused lawsuits to proliferate from environmental advocacy groups, such as the Natural Resources Defense Council (NRDC). The end result was that very few requests for the 301(k) waiver occurred during the entire fourteen years it was available.

A proposal for new legislation was drafted in 1994 by an IP3 Focus Group. This new proposal was meant to overcome some of the major problems with the 301(k) waiver. The group was formed by the Director of Industrial Pollution Prevention, James Lund, Office of Water at Headquarters. The group's mission was to identify the 301(k) waiver program's

successes and failures and to provide EPA with specific recommendations on how to better promote industrial pollution prevention through the effluent guidelines process. Draft legislation has been submitted for review along with the *"Rationale Underlying the Draft Legislation"*. These reports identify and explain pragmatic, workable solutions which should resolve many of the problems encountered with the earlier waiver program. The overall goals can be summarized as follows:

> "To promote more industrial pollution prevention, the effluent guidelines process must (1) be more flexible, (2) address all media, and (3) impart a pollution prevention *mindset* to everyone throughout the effluent guidelines process." [Abstracted from *Report of the IP3 Focus Group*, 1993, p.1)]

The methodologies for obtaining these goals are elaborated in the *"Rationale Underlying the Draft Legislation"*, and are abstracted below:

> "*Three basic changes* are needed from the old 301(k) provision to make it work and successfully promote pollution prevention and technology innovation. These are:
>
> 1. Industry must be given sufficient time to enable the innovation to succeed. Specifically, up to three years from the date of compliance, which would be up to six years from the effluent guidelines promulgation.
>
> 2. If the industry gets that much time, the provision must require *enhanced environmental results* (i.e., either better results in water or the same results in water with better results in other media). Modifications are granted only for enhanced results, and not, for example, with simply a lower-cost technology.
>
>   All water quality standards of receiving waters must *always* be met -- no matter what. Industry is never allowed to violate them.
>
> 3. The *tradeoff parameters need to be pre-defined up front* but still allow for regulatory flexibility, such as in providing for enhanced results, in #2, above.
>
>   The U.S. EPA is given the authority to establish pre-defined reduction parameters as conditions of the modifications, *but is not required* to do so, thus providing U.S. EPA with flexibility. Establishing the pre-defined reduction parameters should not be a resource-intensive task, but will probably be done through a regulatory document other than the effluent guidelines."

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Through these three main points, the focus group felt that all stakeholders would get what they need to make this provision work. *Industry* gets time and flexibility. *Environmental advocacy groups* get enhanced environmental results. *Regulators* get a more normal, standardized process, putting less strain on resources.

Some of the finer points within the *Draft Legislation*, included in the *Rationale*, are the following:

> "The draft provision provides for a permit *modification* rather than a "waiver." Modifications already have established procedures, whereas "waivers" do not."
>
> "The term *"innovative"* is not defined in the provision (that should be left to the regulations), but the provision implies a relatively broad definition of "innovative." For example, there is no requirement that the innovative process or technology has to be previously undemonstrated or have industry-wide applications. Criteria like these are problematic and restrictive in their interpretations and often seem not to foster desirable ends within a real world context."
>
> "The provision applies to both new sources and existing sources and to industries both with and without effluent guidelines. Strict monitoring of the progress during the period of modification is required, with the intent that permanent attainment of the enhanced environmental results, going beyond the enforceable standards, will be assured. A time line of the steps being taken to demonstrate adequate progress could be required. The permit holders will always eventually meet or do better than all applicable standards, while still preserving the other gains."
>
> "And finally, a good-faith effort will be considered in the reduction of penalties which can vary with the capital cost loss sustained by the facility, or other factors."

Predictions concerning the overall benefits of the Draft Legislation as proposed by Lund's Focus Group indicate that pollution prevention methods using innovative technologies will increase significantly. Permit modifications for innovative technologies will become more commonplace, and not be perceived as confrontational. The normal rule-making process for effluent guidelines may be shortened because there will be less litigation from industry and environmental groups over the issued guidelines. More effluent guidelines would, therefore, be promulgated quicker, resulting in cost savings to all stakeholders and, over

time, greater environmental protection would result.

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Barriers are removed from the NPDES permit process by providing regulatory relief; case study

An important barrier to the installation of both conventional technologies and innovative technologies for wastewater treatment has been the sometimes slow and tedious review process required to finalize a NPDES discharge permit. Cutting edge technologies are more likely to experience lengthy delays, even in the best of circumstances where adequate demonstration data *are* made available, simply because they are unknown and unproven at full scale. The permitting process for innovative technologies, therefore, may go through a much more complex review process, often involving a review board which includes permit writers who specialize in an area appropriate to the proposed technology. It has been the experience of many innovators of new technologies, such as Solar Aquatics (discussed later in this study) that approvals seem to be sent to higher and higher levels of authority, adding additional layers of red tape as their application moves around different governmental departments. This has been known to occur at both the federal and state levels.

Discharge permits are required for commercial enterprises, industries and municipalities which release wastewater into surface waters in the United States. Permits must also be renewed every five years, according to the 1972 Clean Water Act. These requirements have led to a tremendous backlog of permit applications or renewals in permitting offices all over the country. Ways to improve the permit processing format are needed.

Recent efforts are being made by EPA and by the NYS Department of Environmental Conservation (DEC) to end this seeming "ping-pong" syndrome, reduce unproductive red tape and improve the efficiency of permit processing procedures.

New York State's environmental benefit permit strategy

New York is a fully authorized State which processes its own discharge permits through the New York State Pollutant Discharge Elimination System (or SPDES) permit program. The SPDES permits include discharges to groundwater, whereas the federal NPDES permits do not. In New York, the renewal process in the past included DEC administrative and technical reviews plus public notification and review of the draft permit. It typically took about a year to complete the process to renew a general permit. As permits became more numerous and more complex and staffing levels relative to workload fell, a backlog of permits began to accumulate. The Division of Water, which manages the

SPDES permit program, was unable to process permits within one year. The backlog, which was maintained chronologically, peaked at 450 permits.

Frustration built for all stakeholders, including New York's permit writers. The environment suffered. Summarized from the DEC's *Water Bulletin* (1992):

> "Permits that sorely needed to be modified to protect the waters of the state were stuck in the bottom of the chronological review pile. Other permits that needed only renewals, not modifications, were being subjected to the same rigorous technical review as those requiring major modifications. This seemed to be an inefficient use of staff time."
>
> "We had to find a better way to do business," said Daniel Halton, director of the Department of Water. "Work kept piling up. The way we did business in 1972 was not working well for us now."

The Division of Water needed a new program to deal with the growing backlog of new permit applications, modifications and permit renewals. Solutions were sought which could more efficiently manage the workload while being more environmentally responsive. In 1992, the Division created a program specifically aimed at simplifying the permit review process while maintaining high water quality standards. Through this program, permits are no longer reviewed in chronological order as they expire. Rather, they are rated and prioritized, based on the environmental benefit that would be achieved. This program is called the *"Environmental Benefit Permit Strategy"* or EBPS.

Halton explained the three major components:

1. *New permits* follow the same rigorous procedure as has been required in the past. In one year, there may be several hundred to a thousand new permit applications for small discharges where new construction is occurring. This would include commercial structures, such as restaurants. There are only a handful of "major" permits in a given year.

2. *Permit renewals* will be handled as an administrative procedure, using a short renewal form filed when the permit expires. Technical staff are usually not required. Permits must still be renewed every five years, following the federal mandates.

3. *Permit modifications* will be reviewed by the Department of Water technical staff in priority order, based on a ranking system developed by the Environmental Benefit Permit Strategy. Modifications of a SPDES permit can occur when there is a change in regulations, a change in the operation of the industry or a compliance problem. Either the permittee or the agency can request a modification.

The ranking system enables the DEC to direct its attention toward permits that have the greatest potential for causing significant environmental harm. The ranking system for permit modifications is based on a "Permit Priority Score" and "Environmental/ Water Quality Enhancement Multipliers." First, a Permit Priority worksheet is used to rate the application based on fifteen factors on a scale of one to ten. Examples of the fifteen factors include *"Permit needs toxicity testing"* (five pts.) or *"Permit needs to be adjusted due to Consent Order or Permit Non-Compliance Issue"* (ten pts.) Each of these fifteen factors are then scaled up with a multiplier to determine if the permit will result in major, moderate or minor improvement to the environment. The multipliers are for ten points, five points, and one point, respectively.

A score is given by summing up these multiplication factors. A longevity score, based on the length of time that has passed since the permittee filed a long SPDES application is also reflected in the final score so that *all* permits will eventually be reviewed. The final score establishes the priority of the permit, with high scores indicating high priority. The ratings are subject to hearings and public review through Freedom of Information Laws. A listing of these ratings can be obtained from the DEC. Public notification is given to allow for a 30 day review, during which public comments are accepted for new or modified permits.

A workshop was recently given in Albany, NY to describe the EBPS program and discuss its merits. The attendees represented various permittees and regulators. Some disadvantages of the program are summarized in the comments below:

- When changes in regulations occur, a permittee can be suddenly out of compliance and end up with a very high score. They are given an 18 month compliance schedule, which is usually not enough time to remediate a problem.

- Public relations for a company can be seriously impacted in a negative way

by the publication of the Ranking List, which identifies high ranking scores. The list can easily be misinterpreted as a measure of the worst polluters, or a "bad guy/good guy" list. The is not an appropriate use of the list. DEC agreed that the list was not meant to be used in this way. They plan to more clearly inform the public about the correct interpretations of the scores.

- The more complex industries are subject to different categorical effluent permit guidelines, which result in *annual* permits (rather than every five years). These require significant manpower and are very costly.

- It seems that there have been misapplications of the multipliers, where a permittee's score is most directly impacted. There need to be more definitive guidelines to eliminate subjective decisions.

These concerns will likely be addressed by DEC in the near future. Overall, the Environmental Benefit Permit Strategy has resulted in a greatly reduced backlog of permits and has dramatically improved efficiency. The technical staff is better able to focus its expertise on the complicated permits and on those which have a greater potential impact on the environment. Permittees no longer have to wait for routine renewals, but when there is a more complicated permit, they get the attention they need. Furthermore, local citizens benefit from a cleaner environment. This system has drawn national attention. Since its inception in April of 1992, it seems to be achieving the main objectives for the benefit of all stakeholders, applicants of innovative technologies included.

Routine subsurface discharges will be certified by licensed engineers

In an effort to streamline the process for obtaining routine sanitary waste permits, David Sterman, deputy commissioner for environmental quality for the NYS DEC announced in a recent press release a new, simplified regulatory procedure (May 26, 1995). General permits will still be issued under the SPDES program, and can authorize private, commercial and institutional subsurface discharges of 1,000 to 10,000 gallons a day of treated sanitary wastewater. Under the streamlined application and verification procedure, applicants may renew an existing permit or apply for a new discharge permit simply by completing a form that acts as the application, permit and discharge

authorization document. (Previously, these were all separate functions).

Some innovative and alternative technologies are ideally suited for small, subsurface discharges. Since these subsurface discharges have the potential of affecting groundwater, applicants may need to obtain approval from a county or city health department in addition to the SPDES permit. In other areas of the state where there is no health department oversight, an engineer licensed to practice in New York state will certify to DEC that the treatment facility was designed and constructed in accordance with DEC standards.

"Wastewater discharge systems of this size generally have a standard design and therefore do not require a lengthy review process," stated Sterman in his recent press release. "The general permit prescribes disposal system design and construction standards and contains operational requirements that ensure wastes are treated and discharged in an environmentally sound manner."

This, however, is the first instance under the SPDES program in which a professional engineer's certification will be relied upon in lieu of review and approval by DEC engineers. Certain environmentally sensitive areas in the state are excluded. The objective of this new system is to allow technical staff at DEC to redirect efforts and to concentrate on higher priority problems. This program should dovetail nicely with the Environmental Benefit Permit Strategy, described previously, to result in further increasing the efficiency of New York's permit process.

EPA's initiative to reduce NPDES reporting helps both conventional and innovative technology permit holders

EPA New England Regional Office was asked in March, 1995 to submit suggestions for a 25% reduction in reporting requirements associated with the federal NPDES permit program. The objective was to provide regulatory relief from monitoring and reporting requirements without jeopardizing water quality. This was requested through a memorandum addressed to Gerald Potamis, chief of the wastewater management section at the New England Regional Office. The memo also invited the suggestions of other EPA staff. It stated:

> "This is an opportunity to be creative without being encumbered by existing regulations.

A few examples could be (1) quarterly DMR submissions for Minors and bimonthly (every other month) for Majors, or (2) eliminating the need for categorical industries to report pollutants that they do not use but are included in the national standard."

The results of this request are forthcoming. It is likely that a number of the barriers to innovative technologies that are discussed in this report will be addressed by this Regional initiative, and may provide models for other regions or states, as well.

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Susan Balmuth, Workshop Leader, Environmental Benefit Permit Strategy. Public Participation Section/NYS Department of Environmental Conservation: Albany, NY. (518) 485-8743.

Daniel Halton, P.E., Director of Wastewater Facilities Design. Division of Water/NYS Department of Environmental Conservation: Albany, NY. (518) 457-1067.

Gerald Potamis, Chief, Wastewater Management Section. U.S. EPA New England

Regional Office, Boston, MA. (617) 565-3575.

A corporation finding variations among states permit requirements; critical incident

American Crystal Sugar is a small manufacturer of sugar, based originally in North Dakota. Joel Smith is the Environmental Manager for American Crystal and he oversees all necessary environmental permits. The company's wastewater discharges are nominal, with seasonal peaks. During the production of sugar, a holding lagoon is used in the winter for wastewater storage. For a two to three week period each spring, the winter buildup is discharged following the required treatment of the effluent. This is an annual event that occurs only during these weeks in the spring.

The original plant in North Dakota uses a constructed wetland system to treat the factory's effluents. It was constructed under the guidance of the Tennessee Valley Authority, following a small community demonstration project at another site in North Dakota. American Crystal Sugar funded their entire wastewater treatment project (because industrial treatment facilities were eligible for Construction Grants funding). Smith has been very pleased with the results.

> "This system has worked well for us," stated Smith. "It lowers the ammonia by ten fold, and reduces the BOD and suspended solids to within our permit limits. You'd think that the regulators at our second, newer plant in Minnesota would take this successful implementation of wetland technology into consideration in our permit application there."

American Crystal Sugar's new plant in Moorehead, MN is planning to use the same constructed wetland technology in very much the same way. However, additional regulatory barriers are harming the cost-effectiveness. The state of Minnesota is writing permits for the constructed wetland treatment system for the sugar factory as if it were a municipal sewage treatment plant. Smith is required to place a 12-inch clay liner under the constructed wetland, which already is designed in an area of natural clay. (North Dakota required no clay liner.) The wetland will hold about 6 inches of water; the state wants to be sure the water is contained.

Smith also mentioned as problematic the monthly discharge report he is required to fill out for Minnesota. This ten page monthly report is appropriate for the 2-3 week period when

American Crystal Sugar actually discharges the winter buildup. For the other 11 months, he checks off one box on the 10 page form and dutifully sends it in to the state.
The lack of flexibility is an obvious concern for Smith. He is managing to make the system work, but feels the affects of the clear distinction between the regulatory requirements of the two neighboring states. Smith views the Minnesota regulatory requirements as unnecessary and costly mandates which act as definite barriers to those considering constructed wetland technology for wastewater treatment in Minnesota.

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Joel Smith, Environmental Manager, American Crystal Sugar, Moorehead, MN (218) 236-4347.

Regulatory barriers with a constructed wetland as experienced by Shell Oil Company; critical incident

The experience of Shell Oil Company (Shell) provides a clear example of a barrier to innovative technologies for wastewater treatment that is created by the three-year statutory deadline within the Clean Water Act. An oil refinery owned by Shell was forced to meet NPDES discharge permit requirements by dilution into a larger body of water, rather than being allowed to try promising constructed wetland technology which would enable removal of the contaminants. The issue was the removal of metals, particularly for zinc and copper, within a stringent compliance schedule from the effluent resulting from a major refinery in Norco, Louisiana.

Norco is located about ten miles west of the New Orleans airport. The discharge from the refinery had become the main headwater for a small bayou, which had created a wetland. During the mid-1980s, the Shell refinery was periodically unable to comply with Louisiana State Water Quality Standards, thus violating the standard for Chronic Toxicity tests for zinc and copper. In 1988, Shell was required to cease the discharge entirely out into the bayou, since a "dilution solution" was extremely limited. The complete removal of the effluent would effectively cut off nearly 100% of the headwater for the small bayou, destroying the wetland environment it had created. The nearest discharge site which could provide the necessary dilution was the Mississippi River, two miles away.

"This was real bad news," stated Dr. Philip Dorn, Sr. Staff Research Environmental Toxicologist. "The amount of metals in the effluent that we were exceeding limits on was minimal, something like 22 ppb for copper rather than 20 ppb. We also know that the Chronic Toxicity test can produce variable results, which additionally makes our violation questionable." Shell contested the NPDES permit requirements based on their contention that the test is unreliable, as well as some other administrative issues. However, by 1991-1992, they still had no response to their complaint, and therefore had begun construction of a pipe to the Mississippi River in order to meet Shell's compliance schedule.

A two-mile pipeline construction was not a simple job. Robert Kuehn, Project Manager, described the work: "The pipeline was one yard in diameter. It had to be run through the middle of our operating equipment within the refinery, with pump equipment at various stations. A lot of equipment had to be moved or built around. The final cost? Ten to fifteen million dollars." The final result of the project would be dilution of the pollutants, not

pollution reduction. Dilution of pollutants is an accepted procedure by EPA Region 6. According to Kuehn, there was no known method of treatment at the time other than dilution.

During the pipeline construction, a new catalytic cracking unit was added to the refinery in 1991-1992, creating a second outfall. The results of a literature search by Shell introduced the concept of constructed wetland technologies as a possible solution to treat the wastewater effluent from this second outfall, as well as the original one. The idea was seriously studied by Shell. Some preliminary laboratory results suggested that a constructed wetland had strong potential for pulling the anionic metals (zinc, copper and lead) out of the water and concentrating them in the roots of wetland flora and in the sediment. Given this finding, Shell proposed to EPA the use of constructed wetlands as an alternative to the pipeline. Even though the pipeline construction was already in progress, the cost savings and public relations benefits would outweigh the cost of abandoning the pipeline. "The bayou ecosystem could be salvaged, which was a much favored solution to local environmentalists," stated to Kuehn. Ed McHam, EPA Region 6 Environmental Engineer in the Industrial Permits Section, reviewed the proposal with interest. Shell was already one year into their compliance schedule; only two years remained. The constructed wetland treatment offered a promising solution, which would include an enhancement of the environment through the removal of metals from the wastewater rather than the dilution method. Dr. Dorn explained, "During the pilot studies, Shell prevented wildlife exposure [to metals] with a thick clay liner used in the treatment cells. Giant bulrushes we planted were able to sequester the metals at the roots within a treatment cell. This concentration of metals, particularly zinc, removed the toxics from water and therefore, the ecosystem." The treated effluent could also provide continued headwaters for the bayou, which would have been virtually eliminated by the pipeline. Local officials and environmentalists advocated this constructed wetland technology as an innovative solution.

Despite it's potential, however, Shell researchers could not guarantee that they could meet the compliance schedule in just two more years. If the constructed wetland failed to reach their mandated effluent guidelines, Shell would be liable for penalties. "It would have taken an act of Congress to change!" exclaimed Kuehn, "The regional EPA folks really tried to help us. Nobody screwed up, but between our attorneys and EPA, we knew we just couldn't make that schedule if anything went wrong." McHam was forced to make the same conclusion. "We were not allowed to give them more time, in accordance to the Clean Water Act. On this point we simply had no flexibility. We just couldn't help them," he stated.

If Shell had started its research in 1988 when the problem first became apparent, there may have been adequate time to complete the constructed wetland. However, there is

good news resulting from Shell's initial research efforts. Potential savings for Shell may be realized through the use of constructed wetlands for the treatment of their industrial wastewater, particularly as the regulations become more stringent with time. Shell also could gain from positive public relations, since the company put money into research which resulted in environmental enhancement and not degradation. Shell made the decision to continue proactively supporting and funding a wetlands research pilot project.

The pilot project was running in 1995. It is made up of two small wetland cells, which are entirely self-contained. The objective is to determine the most effective method of removal of metals from the wastewater under various conditions and engineering designs. Applications to other specific Shell sites will be sought. According to Dorn, "Shell is not seeking a patent; wetland technology is not new. We will be working closely with an advisory board, made up of representatives from several state universities, U.S. Fish & Wildlife, U.S. EPA, and the Louisiana Department of Environmental Quality." Shell is committed to doing the research to meet their needs and share what they've learned through manuscripts, conference presentations and peer review.

According to Dorn, this proactive stance is a first for Shell. It didn't, however, occur without setbacks. The Louisiana DEQ had mandated specifications for the pilot cells which would virtually eliminate risk of leakage to groundwater, regulating it as a hazardous waste impoundment. Three feet of high compaction clay was initially required to line the cells**.** Dorn, however**,** managed to negotiate one and one-half feet with additional protection provided by a high density polyethylene liner. "Groundwater monitoring wells were also required," added Dorn, "which we think was overkill. It has cost Shell many thousands of dollars, and took us way over budget."

The barriers experienced by Shell Oil Company in its search to utilize a new approach to treat wastewater further emphasized the problems related to the statutory time limitations and gaps in coordination and communication among state regulators and EPA regional offices. Small companies would most likely not have had the financial resources to continue to pursue such an innovative approach.

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Robert Kuehn. Project Manager, Shell Oil Company, Norco, LA. (504) 465-7401.

Edward McHam. Environmental Engineer, Industrial Permits Section, Permits Branch, Water Management Division, U.S. EPA Region 6. (214) 665-7507.

Patent and royalty regulations create barriers; critical incident

Private industry is motivated by profit. Their interest in innovative technologies for pollution reduction and control is not necessarily derived from altruism for environmental protection, but rather from the environmental mandates by state and federal regulators, a marketing strategy or a perceived cost advantage. Certainly, many of the larger industries allocate funds for research and development efforts which target patentable wastewater treatment technologies and products. These products could be used within their own facilities, and perhaps more importantly, could be marketed to other industries, thus providing a new income stream for that company. General Electric and Shell Oil Corporation are examples of such companies. The resources available to large corporations contrast sharply with those of individual inventors of innovative technologies. Individuals, (also profit-motivated) who start up a business, hope to gain a market for the products or processes they have invented. Yet, obtaining patent rights or royalties becomes an obstacle for small business owners in the United States and abroad.

Obtaining patents in the United States requires a great deal of capital investment as well as persistence and know-how. The U.S. Patent and Trademark Office strongly recommends a patent attorney be consulted for any patents filed in the U.S. since the process is so complex. While this may be a regular part of doing business for larger corporations, it creates barriers for small companies and individual entrepreneurs. Ecological Engineering Associates (EEA) of Marion, MA, for example, holds at least three patents for its "Solar Aquatics System," a constructed wetland system used for wastewater treatment which has some unique patentable characteristics. During 1994, the company's total cost for it's annual filing fees and patent attorney fees for four patents with both U.S. and international protection was well over $100,000. Each U.S. patent filed has an initial filing fee of $750 and attorney fees of approximately $5000. If a patent is accepted, there is an issue fee of $1250 followed by maintenance fees every 3.5 years, which total nearly $6,000. Patents normally take 18 months to 2 years to process. For EEA**,** the U.S. Patent and Trademark Office took nearly five years to process their patents. These kind of financial resources are rarely available to small businesses.

In order to minimize such cost barriers, municipalities, small businesses and individual entrepreneurs may try turning to federal funding or loan programs for financial assistance in getting started. Outside funding might be sought during the beginning stages of laboratory research or it might be needed to support a full-scale demonstration project.

However, an important obstacle exists within the overall requirements of many of these funding programs. In order to accept government funding, many funding programs will either require a fee be paid as a percentage of the royalty profits made by the company, or, more commonly, they will not allow the company to make a patent or royalty claim. In New York state's State Revolving Fund (SRF) program, for example, applicants for SRF funding for innovative technologies qualify to receive supplemental loan money as an incentive. Proposals must include an engineering report which describes "information on any applicable patents and royalties... which will establish intent, if any, to place ownership in the public domain or willingness to waive royalties for the Innovative Technology Demonstration project." Specifically, an agreement to waive all royalties is required (*New York State Revolving Fund for Water Pollution Control*, May 1994, p.98). As of the fall of 1994, only one application was made for this additional funding under the SRF program. This was for the Village of Minoa's constructed wetland project, a technology that has not been applied much in northern climates, but, nonetheless, is probably not patentable since constructed wetland techniques are already considered "conventional" technology in other areas in the United States.

The patent laws themselves are perceived by some as powerful disincentives to innovation. With government involvement, the requirements quickly become complex, requiring the assistance of a patent attorney and a great deal of perseverance from the inventor. In order for a patent to protect the inventor, the unique characteristics must be fully disclosed, i.e. made public. The supporting data stemming from perhaps years of research may also be required to be revealed in the patent. According to Glenn Reinhardt, Executive Director of the Water Environment Research Foundation, "Once the information is released, "look-alike" products begin to proliferate on the market." The only recourse for the inventor is an expensive process of pursuing litigation against a patent infringement.

Larger companies have patent officers and in-house attorneys who will commence litigation, should patent infringements become apparent. Mr. Robert Walker, Marketing Manager for Bailey, Fischer and Porter, doesn't see any way of changing the legal system. His company is the second largest producer of ultra-violet disinfectant systems in the United States. His job is not only to market the company's products, but also to watch the competition for patent and trademark infringements. Walker suspects that most of the infringement possibilities arise from product literature for these new products. "A typical scenario," Walker described, "is when someone sees our literature and says, 'Hey, that's a good idea!,' without perhaps realizing it's patented or that a patent is in process. I notify our general counsel, and a formal letter gets sent out. If they don't back off, we start a litigation process. In fact, we have one in process right now."

Walker has the advantage of an internal legal system and a large corporate structure which support his position in investigating the competition. He feels that the patent

process is not a deterrent in R&D efforts or in marketing arenas, but is a necessity in doing business. "It is preventive medicine," stated Walker, "and must be seen even by small businesses as a cost they must bear."

Patents, of course, are not required for innovative technologies to be marketed in the United States or abroad. Many research and development operations at municipalities and private corporations choose not to pursue a patent for a particular process or technology on which they are working. The example of Shell Oil Corporation and its work on a constructed wetland technology which was previously discussed is one where Shell is developing a process which has the potential for being patented, but the patent will not be pursued. As stated by Dr. Philip Dorn, Sr. Staff Research Environmental Toxicologist for Shell Oil Corp., "Shell's intent is to share the research data openly." Moreover, Dorn feels that obtaining a patent for their wetland technology might have proven to be difficult. Even though it is being applied in a unique setting, constructed wetlands have been around for over 25 years for other applications. "Shell," said Dr. Dorn, "is not entirely altruistic. We hope to mitigate future compliance requirements issued under the Clean Water Act [for effluent guidelines for metals]. While nearly all of our facilities are now operating with BAT [Best Available Technology], we anticipate stricter requirements in the future, and we wan

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Glenn Reinhardt, Executive Director, Water Environment Research Foundation, Alexandria, VA. (703) 684-2470.

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674-6339 or (800) 829-6772.

4. Analysis of Federal Grant and Loan Programs

Underwriting the costs of innovative technologies through government funding is viewed by many stakeholders as an essential component in providing an incentive for municipalities to consider innovative alternatives to proven, conventional technologies. The risks, otherwise, are far too great. The Innovative/Alternative Incentive Grant Program's strengths and weaknesses are described below, highlighting the compelling viewpoint from the state of Illinois and stories of several failed technologies which were funded under the I/A grants.

The Innovative/Alternative Incentive Grant Program

The Federal Water Pollution Control Act of 1972 was the first nationwide attempt at setting technology-based as well as water quality-limited effluent standards. It included funding for sewage system construction through construction grants. Congress quickly recognized that this construction grant program lacked financial incentives for municipalities to consider anything but conventional, proven treatment methods, resulting in very few technological innovations. Therefore, Congress passed the 1977 Amendments to the Clean Water Act (CWA) to promote the development of innovative wastewater treatment processes through strong financial incentives. Congressional intent was to establish support for technologies that offered lower costs or greater environmental benefit than conventional treatment methods. Innovative and Alternative (I/A) Technology grants were established as part of the Construction Grant program, and were funded by Congress through the 1990 Fiscal Year. After 1990, the State Revolving Fund (SRF) replaced the Construction Grant program by providing low-interest l*oans* rather than grant support.

The 1977 I/A program offered financial incentives to states by increasing the amount of the federal grant share for projects using "innovative" or "alternative" technologies. From 1977 to 1984, eligible I/A construction projects were 85% funded through federal grant money while conventional construction projects received only 75% funding. The incentive to try innovative or alternative systems was even stronger between 1985 and 1989; qualified I/A projects received 75% funding and conventional projects received only 55% funding. The CWA Amendments also established a Modification/ Replacement (M/R)

Grant program which could provide *100%* of the cost of correcting I/A projects that failed or did not meet design standards. These combined programs were powerful financial incentives for communities across the United States to consider seriously I/A technologies.

Many stakeholders interviewed for this study considered the I/A grant program and the accompanying M/R Grant program to be *essential* components for them to consider or recommend innovative and unproven technologies. Without such financial incentives, the risks could not be justified. Conversely, another group of stakeholders found serious flaws with the I/A Grant incentives, which inadvertently promoted inappropriate technologies particularly for small towns who could least afford failures. James R. Leinicke, Manager of the Grant Administration Section for the Illinois EPA, articulates this problem in his "Perspective" for the state of Illinois, which follows. Here, Leinicke described Illinois' negative experiences with the former I/A program. Some states chose not to participate in the program with their additional grant allotment being lost to other states. The analysis of the I/A program below is based on comments received during interviews and a review of the literature.

The source of funding for the Innovative/Alternative Grant program was designated from each state's Construction Grant fund. The amount was determined through a formula which provided more money to the more densely populated states. States were mandated to set aside 2% of their Construction Grant fund for I/A projects during 1979-1980, 3% in 1981 and 4% thereafter. The 1981 CWA Amendments gave states the option of increasing their set-aside I/A money to a maximum of 7½%, but required that 0.5% of their allotment be used to fund innovative projects. It was at this point that the definitions which distinguished "innovative" from "alternative" became a real source of contention among regulators. U.S. EPA's *Report to Congress* (1989) distinguished these technologies with the following definitions:

> "*Innovative technologies* are wastewater treatment processes or components which are not fully proven in the circumstances of their intended use but, based upon documented research and demonstration projects, appear to offer the promise of benefits which outweigh the potential risks of failure. Projects are designated as innovative on a *case-by-case basis* if they are significantly different from proven conventional or alternative technologies and if they offer the potential to significantly advance the state-of-the-art in terms of life cycle costs, environmental benefits, or more efficient use of energy and resources." (p. 2)

> "*Alternative technologies* are fully proven wastewater treatment systems that reclaim or reuse wastewater, productively recycle wastewater components, recover energy or eliminate pollutant discharge. Specific alternative technologies include onsite treatment or alternative wastewater conveyance systems for small communities, land treatment of wastewater and sludge, direct reuse (non-potable) of treated wastewater, aquifer recharge, composting, co-disposal of sludge and refuse and methane recovery and use. Alternative technologies typically provide a cost savings compared to conventional treatment because of lower operations and maintenance costs or cost recovery through productive use of wastes." (p. 2)

Distinguishing between innovative and alternative technologies on a "case-by-case basis" resulted in conflicting opinions in some cases.

According to the 1989 *Report to Congress* prepared by EPA, the I/A program was "tremendously successful at promoting the development and application of more cost effective, environmentally sound wastewater treatment technologies, especially in small communities" (p. 3). In fact, approximately 2,700 I/A technology projects were funded: 2,100 alternative projects in which the federal investment totaled $3.3 billion and 600 innovative projects in which the federal investment totaled $1.1 billion. As of 1987, nearly half of these projects were in operation, most of them functioning as expected.

Failures were anticipated under the I/A program; the Modification/ Replacement Grant program was to provide the insurance package to financially support communities which were willing to try unproven technologies. According to the 1989 *Report to Congress*:

> "Innovation inherently involves increased risk; *a reasonable number of failures is therefore an indication that a program is pushing technology to its limits*. The failure of some I/A technologies is therefore expected and is not an undesirable facet of the I/A program. One must bear in mind that "failure" as the term is used here refers to the inability of a project to meet design performance expectations due to something inherent in the technology. Conventional technology projects sometimes also fail to perform to design expectations. When this happens it is not generally due to anything inherent to the technology since, by definition, conventional technology is fully proven and widely utilized. Conventional technology failures, unlike most of the I/A failures, are attributable to poor operation and maintenance, poor design, poor construction and/or excessive infiltration and inflow." (p. 6)

The 1989 *Report to Congress* found that 70 of the I/A facilities (or approximately 5% of those in *operation*) had experienced performance problems. Of those in operation, 41 were innovative (equivalent to 15% of those in operation) and 29 were alternative (equivalent to 3% of those in operation). Of those reviewed for the Modification/Replacement grants, 12 M/R grants were awarded before the 1989 report and 58 more were under some stage of review. Some state employees complained about the process they were required to go through in order to obtain the Modification/Replacement funds from U.S. EPA. Thomas Lang, Environmental Engineer & Water Compliance Officer in New York state said "I remember some pretty catastrophic failures in New York under the I/A program, particularly with oxidation ditches in LeRoy and Cortland. When we applied for Replacement funds, we had to prove there was a fundamental design problem. Then we were asked 'Did you sue the engineer?' Often, the engineers were residents and long-time consultants in these small towns. It created real serious tension. The towns did not want to sue their engineers who had faithfully worked for them for decades. We were real disappointed with EPA on their lack of follow-through."

One method of measuring the effectiveness of the I/A incentive program is to analyze each state's funding to determine what portion was left unobligated. All Construction Grant allotments, including set-asides for I/A projects, were made available for obligation during the fiscal year in which they were awarded and during the succeeding fiscal year. Funds not obligated by a state during this two year period were lost, and were reallotted to other states which had no unobligated balance. Some states regularly lost funds; others had problems early in the program but became successful at obligating their set-aside in later years. Still others who had been successful at obligation of I/A funds during the early years later lost their allocations.

The 1989 *Report to Congress* studied the unobligated funds of the I/A program from 1979 to 1985. It stated:

> "A total of 26 states, five territories and the District of Columbia failed to obligate I/A funds during 1979 to 1985. Approximately 8.5% or $54.1 million of the total I/A set-aside funds for fiscal years 1979 to 1985 ($626 million) was unobligated. Unobligated innovative funds were approximately $10.2 million or 1.6% of the total set-aside for 1979-1985. The percentage of yearly unobligated funds ranges from 7 to 13% of the total I/A set-aside. Note that larger percentages of *innovative* funds were unobligated during the early years of the program, while the percentages of unobligated *alternative* funds increased from 1979 to 1985." (p. 45.)

Under the early I/A program, many communities rejected additional funding for innovative or alternative technologies for a variety of reasons. The states did not promote the program, particularly to smaller communities, apparently because of a conservative attitude, lack of staff, lack of knowledge about a new technology, and the deeply

entrenched fear of failure. Even partial failure could cost a community millions of dollars in modifications and result in destruction of the engineering firm's professional reputation. These fears, summarized in the 1989 report on Table 8 (p. 49-62), have not diminished.

One specific example from New Hampshire demonstrates a state with unobligated funds. John Bush currently manages the State Revolving Fund (SRF) in New Hampshire's Department of Environmental Services. In New Hampshire, there are *no* innovative technologies being considered under SRF incentives, which provide low-interest loans for the installlment or improvement of wastewater treatment plants.

"Small communities don't want to put any money at all into sewage treatment," stated Bush during a recent interview, "they are reluctant to try anything that is not guaranteed; they don't want to be experiments. They want to be certain of a successful outcome."

The 1989 study reported that in New Hampshire, during the Construction Grant program for 1979-1985, the I/A incentive was used only *once* for an innovative project and 18 times for alternative projects. John Bush noted that the only time he observed any interest in the I/A incentive was when the projects were nearly fully funded (through add-ons) by 95 to 97%. Moreover, Bush remembered problems getting the I/A projects started. For example, a lagoon system had groundwater infiltration. Another project, classified as 'alternative,' was a large covered sand-filter system that had continual problems. The details of these projects are sketchy and not readily available; the files probably no longer exist.

Bush added that the New Hampshire state regulations are not setting barriers for innovative projects; I/A is definitely allowed under the New Hampshire rules. In fact, Bush has SRF funding available for small towns. Yet, if they have to pay the loans back, he feels, they are simply not interested. Bush does intends to allow an innovative [wastewater treatment] project at a solid waste landfill to obligate a portion of the SRF loan money.

In fact, many small communities, such as those in New Hampshire, chose not to utilize the grant money under the earlier I/A program and under the current SRF low-interest loan program. This suggests that, the offered financial incentives were sometimes not powerful enough to offset the risks of using alternative or innovative wastewater treatment technologies.

On the other hand, the grant programs have unquestionably been very important in providing incentives for many projects which were effective in increasing the number of

innovative and alternative technologies for wastewater treatment. There have been over 20 years of government subsidies for construction and improvement projects for sewage treatment facilities which support EPA's effort to enhance water quality and protect groundwater. Likewise, there has been an evolution in communities' expectations for government assistance in building and maintaining their sewage treatment plants as a part of their infrastructure. Many communities have come to expect the government to share the cost of their treatment plants, and they lose interest when they find that only loans are available.

Diane Perley of New York State's Self-Help program said "Communities don't value their sewage treatment plant like they do their school system, their roads and bridges or even their water supply. They don't like to put money into sewage treatment plants. That's probably because they can't see it and they never even think about it until something goes wrong. Most people really can't comprehend the costs involved in maintaining what is really the most complex component within the jurisdiction of almost any municipality. The attitude we see so often, is that 'our community shouldn't have to allocate money from our already strained town budget for sewage..the government should pay for it' needs to change. I think the Construction Grant programs, as helpful as they were in getting treatment facilities built, have fostered this attitude."

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One state's experience with the Innovative/Alternative grant program: a perspective

Mr. James R. Leinicke manages the Grant Administration Section of the Division of Water Pollution Control for the state of Illinois' Environmental Protection Agency. His agency's experience with "innovative" technologies for the treatment of wastewater has been anything but positive. During the Construction Grant program of the 1980's, the agency optimistically supported funding for the Innovative/Alternative (I/A) program. According to the 1989 *Report to Congress*, the state of Illinois had the largest number of alternative projects funded under the I/A program, totaling 130. Illinois also allocated funding for 26 innovative projects.

"In hindsight," Mr. Leinicke stated, "I recognize that many failures were due to our approval of 'questionable' technology which we permitted on the basis of the added financial incentive, which seemed to outweigh the risk. However, over time, more money was required to document the project, collect data and perform the research needed for the technology transfer component. Many of these technologies worked. However, they did not work well enough for that particular site. Then we had to struggle for supposed 'replacement' funds from national EPA."

According to EPA's *Report to Congress* (1989), the EPA expected some innovative technology projects to fail. "Innovation inherently involves risk; a reasonable number of failures is therefore an indication that a program is pushing technology to its limits." (p. 4) Thus, Congress sought to reduce the risk of failure in the I/A program by providing Modification/Replacement (M/R) grants for I/A technologies that failed or could not provide adequate treatment levels. However, the state of Illinois found that in reality, the EPA Modification/Replacement grant program was not accessible. When requests for replacement were not approved under the federal M/R program, Illinois often ended up paying for the replacement costs themselves.

Another barrier Leinicke experienced with the program was the frequent disagreements with EPA auditors over what constituted an "innovative" design, and at what point does a 'new' technology cease to be classified as 'innovative'? According to the EPA, the term "innovative" does not apply to a specific treatment process, but rather "processes or components which are not fully proven in the circumstances of their intended use but appear to offer the promise of benefits which outweigh the potential

risks of failure". As previously described, **"**projects are designated as innovative on a *case-by-case basis* if they are significantly different from proven conventional or alternative technologies. Innovative technologies contain an element of risk." (condensed from *Report to Congress*, 1989, p.2).

The EPA's definition of "innovative" required wastewater regulators to take into account local variations for the proposed application of a 'new' technology on a "case by case" basis. Yet, Leinicke claims his department had endless arguments with EPA auditors to determine what parts of a system could be classified as 'innovative' in order to be eligible for the I/A grants, particularly when the innovative project was combined with more traditional technologies. *Definitions were a real barrier.*

The following is excerpted from a letter by Mr. Leinicke, dated January 17, 1995:

> "While there were a couple of notable success stories associated with this program, this Agency's conclusion was that *in general it was an ill-conceived effort by Congress to force technology using a basis other than technical and economic merit*. Mandatory set-asides of grant allotments and very substantial grant incentives strongly encouraged political considerations to override sound engineering judgment, with the result that I/A technologies were often utilized under circumstances where the long term public interest would have been better served by more conservative, proven wastewater systems."
>
> A prime example of misapplied technology were the various 'alternative' conveyance systems for small, unsewered communities. Quite a number of small diameter septic tank effluent and pressure systems were built in small communities that were ideally suited for conventional gravity systems. As a rule, there was no advantage in cost, except that the generous grant incentives made the alternative systems appear to be less costly for the small towns. While all of these systems function, many have experienced problems with maintenance and with a lack of internal storage capacity for the inevitable infiltration that finds its way into any sewer system.
>
> Where alternative conveyance systems have been a major success have been in those few places where terrain truly favored the choice of such technology, most notably at the Lake of Egypt Sanitary District in southern Illinois. Ironically, this grinder pump-pressure sewer system was funded with state grant funds prior to the federal I/A program, and was the selected technology entirely due to its technical merits in that application.
>
> In fact, in most cases, *the most successful of the so-called I/A projects were those that would have been built regardless of I/A grant incentives.* Land application of sludge, cost-effective reuse of effluent and methane gas, and simplified small

community treatment technologies were already the rule rather than the exception prior to the inception of the I/A program.

We can really only think of one significant technological advance in this state which resulted from I/A grant incentives. This was the development and application of swirl concentrations for combined sewer overflow (CSO) treatment at the Decatur Sewer District. It is improbable that this particular technology would have been applied to CSO without the I/A incentive and that technology has since proven to be extremely cost-effective. Another successful application of a once 'innovative' technology is fine bubble aeration in activated sludge systems, though this technical advance would have occurred without special grant incentives.

In contrast, our most dismal failure was a community mound system at Waynesville, Il. This was ultimately replaced with state grant money. Waynesville's experience points out what was *probably the greatest failure of the entire I/A program, which was its emphasis on using experimental technologies in small communities that could least stand the cost of failure.* The 100% Modification/Replacement provisions in practice turned out to be an illusion, and as a result, many of these communities are now stuck with troublesome, second rate conveyance/treatment systems with no hope of replacing them."

Based on these experiences, if the grant program is ever available again, Mr. Leinicke believes that the state of Illinois will be extremely cautious about it's use. The agency's feeling is that the new technologies must sell themselves, and that they cannot be forced onto a community which cannot afford to engage in financial risk.

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The innovative "Carver-Greenfield" sludge treatment process:
A technology applied too fast; case study

The Carver-Greenfield "Four-Stage Multiple Effect" process is a unique sludge dehydration process developed originally by Charles Greenfield and Fred Carver during the late 1950's. The first commercial plant utilizing the process to dewater industrial wastes became operational in 1961 and has been used successfully ever since. The process has been particularly successful in the food processing industry, such as the rendering of waste fat and bone during the processing of meat. The main advantage of the Carver-Greenfield process is its energy efficiency. Currently, there are 86 operational plants using the Carver-Greenfield (C-G) technology worldwide.

During the Innovative / Alternative grant program, there was great interest by the EPA, private consultants and municipalities to adapt the Carver-Greenfield process to municipal sewage treatment. Although the process is complicated, it appeared promising. Interest was heightened by the dramatic energy savings anticipated, particularly in large scale operations such as with a large municipal plant. This technology was seriously considered during the oil embargoes by OPEC countries with U.S. Department of Energy forecasting that the cost of gasoline to rise to nearly $4.00 per gallon. The Carver-Greenfield process had proven to be at least four to five times as efficient as alternative drying processes. The following is condensed from "*The History of the Carver-Greenfield (C-G) Process Technology"* (1994):

> "In the early 1980's, the U.S. EPA became interested in the "light solvent" C-G process for possible use in drying municipal sewage sludge. While three heavy solvent plants had been built to dry municipal sewage sludge in Japan, no light solvent plants had been applied to municipal sewage at the time. In 1984, following a *thorough* evaluation (as a part of the Los Angeles OMA project, evaluating sludge management, options further 3 major wastewater authorities in the Los Angeles, CA area) the U.S. EPA declared the C-G process as "innovative and alternative", thereby permitting municipalities to obtain 85% federal grant subsidies for C-G process plants under the Clean Water Act of 1977. As a result, four municipalities quickly contracted to build large light solvent C-G process plants in the U.S.: (a) the City of Los Angeles, CA; (b) the County Sanitation Districts of Los Angeles, CA; (c) Mercer County Improvement Authority, NJ; and (d) Ocean County Utility Authority, NJ." (p. 1-2).

Carver and Greenfield formed Dehydro-Tech Corporation around 1984. It was a small five-person firm with assets linked mainly to licensing fees. The Carver-Greenfield process became a registered trademark of Dehydro-Tech. At about the same time, Dehydro-Tech entered into an agreement with Foster Wheeler USA Corporation, which gave Foster Wheeler exclusive rights to market and design C-G sewage sludge projects in the United States. Foster Wheeler did the engineering and procured the major equipment for these projects. The facilities were constructed by a third firm: Montgomery Parsons, which specialized in water treatment processes, not sludge treatment. However, *all four municipal plants which used the C-G process have failed*.

Each site was funded under EPA's Innovative/Alternative grant program, essentially all at the same time and with very similar designs. There was very little financial risk to these municipal districts. According to Ross Caballero, section head for research at the Los Angeles County Sanitary Districts, "With the grant money we received and with the insurance of the Modification/Replacement program, we had minimal risk. The proportion of money we put in was minuscule, ($8 million of the total $166 million) as compared to what the federal and state government paid." Caballero has almost 25 years of experience researching and testing new technologies for wastewater treatment facilities.

Caballero noted that his district and the City of Los Angeles allowed the new system to be built even though there were early warning signs that the process might not work effectively for sewage sludge. A small pilot was run at the Los Angeles County Sanitary District Research site. It didn't have all the features that the large scale plant would have, but according to Caballero, it was able to test key aspects. The pilot showed that the process did not function according to need. However, the consultants defended the process, claiming that the problems encountered were directly attributable to the small size and characteristics of the pilot. "In our experience, that claim is not unprecedented," stated Caballero. "And, since the financial risk to the Districts was so small, we didn't push as hard as we might have. In retrospect, it's clear that we could have been more insistent in verifying the source of the failures. It is now a $166 million white elephant."

Theodore Trowbridge, manager of research and development for Dehydro-Tech, readily admitted that there were design problems in these four installations. Moreover, communication problems among the numerous groups of professionals contributed to the failures of the systems. Equally contributory was the speed of the decision, and the simultaneous approval of all four plantswhen a full-scale model of the process had never been proven for sewage sludge. ***"****Everyone agrees that they moved too fast, the pressure to use the I/A monies while they were available was great.****"*** Donald Avila, Assistant

Information Officer for LA County Districts, frowns on the 'use it or lose it' policy. "It inevitably causes waste *every* time I've seen it, no matter where it applies. This was so much money that nobody was willing to let go of it." Ross Caballero added, "This was also during a time of serious inflation. Once the money came through, we bought a bunch of the larger equipment we knew we'd need in two or three years, and mothballed it on-site until it was needed."

A brief description of the Carver-Greenfield process helps to illuminate the complexities of the system and the reasons it failed. The system starts by mixing the sludge slurry with a carrier oil to overcome the problems of pumpability and heat transfer. A four-staged evaporation-dehydration system has a series of interconnected pipes which carry sewage and hot steam. Each successive stage of treatment extracts water vapor, and the resulting sludge is then carried to the next stage and used for further extraction of water. The heat of evaporation is maintained by using sealed vacuum piping, with each successive stage utilizing a stronger vacuum. In order to maintain an efficient energy flow, the pipes must be narrow in order to provide the greatest surface area. The end product is a dried sludge which is a flammable, talcum-like powder of nearly pure carbon which can be burned and converted into energy. Not only is it flammable, but it is explosive, requiring that the entire multi-story building holding the dehydration process be bombproofed, in addition to other safety precautions to prevent a spark inside the pipes from causing an explosion.

The Carver-Greenfield system works quite well with the food industry's effluents, which are consistent and non-abrasive. However, municipal waste carries many incompatible and abrasive materials. The City of Los Angeles found the piping clogged frequently. Also, sewage sludge is gritty and sandy. The pipes eroded quickly, requiring early replacement. The plant design did not allow for easy repairs and maintenance; pipes and buildings were constructed too close together. In addition, it was found that the mixture of body oils, soaps and other cosmetics common in municipal waste caused the breakdown of the carrier oils which were required to lubricate the system. Because of the high expense of this carrier oil, a recycling process was then added. Furthermore, during the construction of the Carver-Greenfield plants, stricter air pollution regulations were promulgated under the Clean Air Act. These were especially stringent in Los Angeles, California. Thus, expensive scrubbers had to be added, which not only drove up the cost, but also decreased system efficiency.

Trowbridge blamed additional cost overruns on a high personnel turnover which followed special training programs. "The skills to manage the plant are not difficult, but they *are* specialized. As soon as we trained staff in the management of the facility, they were qualified to accept better paying jobs...and ended up leaving." However, James Wheeler, environmental engineer with EPA Headquarters, feels differently. Wheeler stated that these systems failed to meet projected performance estimates at the municipal sites, adding that even "a team of chemical engineers with Ph.D.s were unable to make the system run up to operational requirements."

Thomas Holcombe, president of Dehydro-Tech argues that the system was never even turned on at the Los Angeles County Sanitary Districts (*The Daily Breeze*, Feb. 6, 1995). The *city* of Los Angeles Sanitary District's plant was completed about two years before the county's. The county system was built nearly identical to the city's plant, and is located just 20 miles away. The day-to-day problems at the city site were made known immediately and were sufficient enough to preclude the county from beginning operation.

In summary, the city of Los Angeles Sanitary District's Carver-Greenfield Dehydration system required large amounts of modification money to try to make it work. According to Caballero, at maximum, they were able to reach only 25% capacity. Even testing it at the Los Angeles County site would have required costly repairs. Despite negative media coverage, there was no point in ever starting the county system. "Since its completion in May 1992, not even a teaspoon of sludge has been fed into the plant," reported Thomas LeBrun (*The Daily Breeze,* Feb. 6, 1995). "The system would require major modifications, costing millions of dollars just to get it started up. Using the plant would double the District's sludge disposal costs from $14 million to $28 million a year." The four original systems have been abandoned. Los Angeles County has no intention of ever running **its** plant.

Dehydro-Tech Corporation has since evaluated the problems experienced at all four municipal treatment facilities. "The good news," stated Trowbridge, "is that we have identified all the problems and we are confident we can economically correct them. We have approached the facilities in Los Angeles county and in Mercer county, New Jersey and, with the support of Chase-Manhattan Bank, we've offered to purchase them outright. We want to correct the problems and make the systems a private enterprise. Our research shows we can still turn a profit and prove our technology will work." Los Angeles **county** has declined, but Mercer county is considering the offer.
Currently, the Los Angeles County Sanitary District is planning to auction off the construction materials as surplus government supplies and return whatever money is left to

the appropriate federal and state funding sources. The city of Los Angeles has converted their experimental system to conventional steam dryers, which are functioning as expected.

If the oil embargo had occurred according to predictions, the value of the Carver-Greenfield system might have been realized. Yet, an unfortunate combination of events has culminated in a significant loss providing a valuable lesson for future applications.

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Failure of a constructed wetland in a small community; critical incident

Wetland treatment of wastewater involves the discharge of effluent that has already been partially treated into either a constructed wetland or, under some circumstances, a natural wetland. The purpose, when designed for municipal treatment, is to further remove suspended solids, BOD, nitrogen and sometimes phosphorous concentrations through the natural biological uptake of wetland plants. Proponents of constructed wetlands for the treatment of wastewater tout the advantages of this method as a "natural" low-cost technology for polishing the effluent. The technology, which is simple to maintain and operate, especially appealing to small communities where the cost of land is not a barrier. According to a study done by Sherwood "Woody" Reed, a well-known wetlands expert, by 1990, the greatest concentration of artificially constructed wetland systems was recorded in Louisiana, Mississippi, Tennessee and South Dakota. The size varied from as small as 10,000 gallons per day (gpd) in El Dorado, New Mexico, to as large as 20 million gallons per day (mgd**)** in Orlando, Florida. (Schutz, 1990).

The Tennessee Valley Authority (TVA) provided technical support for the construction of some of the first wetlands. However, Reed writes that as of 1990, there was still no general consensus regarding design criteria for these systems. Factors such as ideal depth of the water or media, type of media, slope of bed, inlet and outlet construction, etc. had not been determined. Reed, Bob Kuder, and Bob Knight began to inventory constructed wetland systems in 1991, putting together design and performance data (Reed, 1991). Although a thorough study has not been done, it is not surprising to find that by 1995, many of these systems experienced unforeseen expenses and**,** as a result**,** are no longer operational.

Between 1986 and 1991, EPA funded a number of constructed wetlands projects for wastewater treatment under the Innovative/Alternative grant program. Three projects were located in the state of Kentucky. TVA provided the technical assistance for these three projects, only one of which is still functioning today. Most of the technical staff at TVA who worked on these projects are no longer with TVA and could not be located for interviews.

Pembroke, Kentucky was one of the communities to try the constructed wetland technique. With only 600 to 1,000 households to support a treatment system, a low cost solution to treat wastewater was sought. TVA provided construction fundings and technical assistance. I/A funding for monitoring of the project after construction was provided by EPA. Construction began in 1987.

The constructed wetland proved to be difficult to maintain and manage from the beginning. The wetlands were not effective in removing ammonia and other pollutants. According to the mayor, Dorothy Dossett, Pembroke tried for seven years to solve the problems, but the town could not meet the effluent guidelines.

> "Apparently, the particular kind of soil here was not conducive to wetland treatment," Dossett described, "We had a sink-hole in the area; several things did not work correctly."

Mayor Dossett does not know who is at fault for not investigating the soil conditions properly. She feels strongly that the town did not quit prematurely, pointing to the other failed wetland system in Kentucky. Through her experiences, Dossett recommends that other communities considering wetland technology have their soil more carefully tested prior to attempting this particular technology.

Pembroke's solution, as of January 1995, was to completely abandon the wetland treatment system and to hook up to a neighboring sewage treatment plant ten miles away, at Hopkinsville. The state of Kentucky has provided a grant which will cover materials. The installation cost will be covered through in-time services by the town of Pembroke.

According to James Watson, project leader at TVA, there are no more constructed wetland projects being funded or demonstrated by TVA.

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Dorothy Dossett, Mayor. Pembroke, KY. (502) 475-4249.

Sherwood (Woody) Reed, P.E. EEC, Inc., Norwich, VT. (802) 649-1230.

James Watson, Tennessee Valley Authority Project Leader. Knoxville, TN. (615) 751-7338.

5. Successful Wastewater Treatment Technologies: Experiences with incentives and barriers

There are numerous innovative technologies in wastewater treatment in various stages of development and commercialization in the United States, and indeed, worldwide. One U.S. permit writer stated emphatically during a recent interview that "America is based on innovation," suggesting there are a myriad of solidly successful technologies within the U.S. that are supported by private companies, academia and the government. Despite the failures described in Section Four, numerous examples of successful innovative technologies or processes are underway. Some of these have been funded by the various government grant programs described earlier; many, however, have been able to "sell themselves" based on their own merit. Stories of these promising new technologies are described below, along with relevant viewpoints from water quality professionals.

Biosolids (sludge) reuse programs; three critical incidents

Land treatment of sewage sludge (now called biosolids) has been researched and practiced in a variety of settings for 20 to 30 years in the United States. Standards for the use and disposal of biosolids is addressed by recent regulatory changes promulgated in 1989 by 40 CFR Part 122-124 and 501 (Federal permitters of biosolids use disposal facilities), and in 1993 by 40 CFR, Part 503. Prior to these regulations, biosolids were regulated under a number of different Federal statutes with primary responsibility for overseeing biosolids management practices being at the state and local levels. (Bastian, 1994.) These previous regulations varied widely in their comprehensiveness and effectiveness. Through current regulations, however, EPA is attempting to address all biosolids use/disposal practices comprehensively. The new Part 503 technical regulations are risk based; the choice of use/disposal practices will be up to the generator (with the important exception of ocean disposal which is prohibited). (Bastian, 1994.) Part 503 provides national standards for land application, surface, disposal, pathogens, and vector attraction reduction and incineration. Under Part 503, fewer restrictions are imposed on the use of "exceptional" quality biosolids, i.e., those which meet EPA's limits for heavy metals concentrations, "Class A" pathogen density, and which utilize vector attraction reduction methodologies. Therefore, these regulations should encourage and support the introduction of innovative technologies and processes which produce "exceptional" quality biosolids. This allows for broader applications for beneficial use of the by-product in land

applications, such as fertilizers or soil enhancements. The product can be used on agricultural crops (including those consumed by humans) as well as golf courses, gardens, parks, and forest land.

It is not surprising that the decisive barrier to the reuse of biosolids has been public acceptance. However, with our nation's steady increase in the production of biosolids and the difficulties with long-term lagoon storage or land filling, beneficial reuse has become essential. The EPA is very interested in promoting innovative approaches to utilizing biosolids as a *resource* and not a waste product that a municipality must dispose (Bastian, 1994). Likewise, municipalities are eager to investigate innovative technologies which can economically take advantage of the revised regulations. Sludge disposal for a municipality has historically been one of its largest operational expenditures. Public resistance to beneficial reuse needs to be overcome. The term "biosolids" was, in fact, specifically created by the Water Environment Federation to replace the term "sludge," which carried negative connotations. Many environmental advocacy groups have researched the issue, and support beneficial reuse of biosolids with the assurance of a **"**Class A**"** product, which is regulated under Part 503.

The following three innovative processes demonstrate a new approach to the treatment of municipal sewage sludge (biosolids) under Part 503 regulations.

A. N-VIRO Soils: An alkaline stabilization process for beneficial reuse of biosolids; critical incident

N-Viro International Corporation is a recognized leader in the technology and market development for biosolids reuse and recycling. N-Viro's patented product is called N-VIRO Soil. It uses a process which starts with dewatered sewage sludge and yields, in the end, a soil-like product that meets or exceeds EPA's Part 503 standards for sludge management. It also adds nutrients to the soil, such as those commonly purchased in commercial fertilizers. N-VIRO uses an alkaline stabilization process which increases the pH through the addition of cement kiln dust and quicklime to dewatered sludge. This process effectively reduces the pathogenic microbial population in the sludge to below the EPA "Process to Further Reduce Pathogens" (PFRP) standards, producing "a high quality product" which is rated by EPA as "Class A." The pathogen kill is done not solely through the increased pH, but in concert with a temperature increase resulting from the exothermic

chemical reaction as the lime (in the form of CaO) is converted to calcium hydroxide (Ca(OH)2). For a minimum of 12 hours, the sludge stays heated to between 52 and 62 degrees Celsius. According to N-VIRO's promotional materials, "These temperatures will cause pasteurization when coupled to the properties of high pH of 12 and an accelerated drying process" (Burnham et. al., p.134).

The proprietary component of the process involves both the quantity and type of lime added to the sludge. N-VIRO Soil is made with 30% (by weight) kiln dust, as opposed to traditional alkaline stabilization processes which use closer to 5% pebble lime. An additional unique feature, as compared to other sludge stabilization processes, is that the product is pasteurized and not sterilized. "This unique fact gives our product a very important advantage," stated Christopher Mahoney, Executive Vice President and General Manager. "Pasteurization kills the human pathogens but allows for the natural soil flora to survive. This means that once the treated product is used as a fertilizer in a farmer's field or as a soil amendment, it still contains its natural immunity against airborne viruses and bacteria. This reduces dramatically the opportunities for our product to develop odors. Odors are the main cause of instant rejection by consumers. If the N-VIRO Soil gets wet or becomes anaerobic, such as when a truckload is delivered to a farmer, prior to spreading, it should remain odor-free for some time."

The company, which originated in the late sixties with other biosolids technologies, now has more than 40 installations worldwide, and has recently become a publicly-owned company. N-Viro International Corporation proudly stands behind its product. It was recognized in 1990 by The National Environmental Awards Council for Environmental Achievement, presented the 1991 President's Award for innovation and excellence in The Environment and Conservation Challenge, and has received numerous other awards. What is the nature of their apparent success? N-VIRO is becoming an established process that can sell itself based on its own merit as an economically effective sludge management process, given the correct circumstances. The process has been proven to meet EPA as well as many state standards for Class A sludge. New regulatory mandates which prohibit ocean disposal of sludge and added restrictions through Part 503 have been the driving force in *new* installations. Still, there are other incentives which have promoted interest from municipalities to consider the N-VIRO soil

process.

N-VIRO was developed to meet the needs of the Toledo, Ohio municipal sewage treatment plant which was facing extreme public opposition due to odors from the existing lime-digested sludge system. A consortium between the public municipality and the private sector formed the foundation for research and development, with N-VIRO's J. Patrick Nicholson as Chairman and Chief Operating Officer. Nicholson was supported by faculty at the Ohio Medical College in Toledo's microbiology department and the Ohio State University's agronomy department. Nicholson, the persistent idea-initiator, recruited the research expertise of Dr. Jeffrey Burnham, a microbiologist, to determine the pathogen kill rate. Dr. Terry J. Logan later joined the research team as an agronomist to determine the product's potential for beneficial use. Today, both professors firmly support the N-Viro process. It can be used to effectively manage the disposal of sludge for many municipalities. N-Viro Corporation's roots are still linked closely to their enthusiastic and industrious Chairman and CEO, Patrick Nicholson.

A significant factor which can be attributed to N-Viro's success is the Corporation's *emphasis and focus on positive public relations and on marketing*. We have already seen that public acceptance is *the* key barrier to many innovative reuse or recycling processes for sludge (or biosolids). The promotional materials for N-Viro have been professionally produced. They address frankly the questions and concerns which communities and potential end-product users might have regarding safety, odors, cost and effectiveness.

N-Viro Agents are licensed throughout the world, but are concentrated in the United States. These licensees have the full range of service options they can offer to potential users, tailored to meet the needs of the user, whether turnkey, publicly owned or privatized. N-Viro staff also provide the municipality and/or engineer with the professional support they might need, at no cost to either. "When requested by the licensee, N-Viro will provide public information seminars for public officials, health officials, elected officials, public managers and their consultants, public interest groups, neighbors, farmers, medical services, etc. to present environmental and public service aspects of the N-Viro technology." (There is a Difference...N-Viro Soil. 5/94). This claim was validated by Mark Gleason of Waste Streams Environmental,

Inc., who is a licensee in central New York state.

Waste Streams Environmental, Inc. is licensed by N-Viro to utilize the proprietary N-VIRO process. They currently manage the sludge treatment process for the Syracuse, NY municipal sewage treatment plant using the N-Viro process. Mark Gleason, Product Manager, described his experiences with N-Viro during a recent interview and tour of the Syracuse operation. While the process does what it claims to do, his staff monitors it vigilantly with the assistance of computer operated controls. The pH and temperature are frequently measured during various treatment stages. Monitoring must be done continuously, requiring staff 24 hours a day, seven days a week.

Gleason discussed some of the barriers faced by Waste Streams Environmental, dealing almost entirely with gaining public acceptance. "While we were getting the process online in Syracuse, we simultaneously had to develop a market for the treated sludge," Gleason remembered. "I spent hundreds of hours trying to educate people, sharing with them the research and the facts. We met with anyone who would listen. We wanted to target the farmers. They, of course, have large scale applications for the N-Viro soil, and would make our marketing efforts much more economical." As, customer support is taken very seriously by Waste Streams Environmental, it was Gleason's job to interview each farmer (their clients) and provide individual instruction about how to properly put down the N-Viro soil as a fertilizer. For the first two years, the product was given away to farmers in order to promote business. Now, there is a nominal charge. Gleason noted that the give-away program generated some unforeseen problems. "We found that when the stuff was free, farmers would tend to leave it in their fields in a mound for extended periods of time. Odor problems start to occur when piles were left for several weeks in standing water," added Gleason. "We are extremely careful about handling any kind of complaint, regardless of whose fault; one negative rumor or story in the press could take years to recover from. So, at our expense, we'd go back to that farmer's field and haul it away. Funny thing, once we started charging our nominal fee, the farmers seemed to take it all more seriously and follow through with spreading it the way they had been instructed."

Another barrier to farmer acceptance originated from the Farm Credit Banks which finance many of the largest farms in central New York. Farm Credit

would not validate the safety of the N-Viro product, despite its being approved by both the EPA and New York State Department of Environmental Conservation. Local Farm Credit representatives would attend town meetings and raise questions and doubts with little scientific evidence to back their resistance. "Each time they attended a meeting, they would come up with a different concern or constraint," stated Gleason. "They threatened to pull loans from the farmers if they used N-Viro. It wasn't until some of the bigger farmers who wanted to support our product, decided to use that Farm Credit started to reconsider." Eventually, Waste Streams gained approval by Farm Credit, with the implementation of Farm Credit's "Four Point Policy" for land application. These requirements included obtaining *product liability insurance* for $10,000,000. N-Viro claims that none of their competitors have product liability insurance and the Corporation now uses it as a powerful marketing tool.

The biggest break in gaining pubic acceptance came from Dick Dodge from New York state's Agriculture and Markets Department. Gleason proudly pulled out a copy of Waste Stream's *"Agricultural Liming Material"* license. "When Dodge came to the next confrontational town meeting where the town was threatening to pass an ordinance against the use of N-Viro, Dodge stood up and voiced his personal support for the product, as well as the Department's support. He stated how N-Viro has been approved by EPA and NYS DEC and now it was licensed by Agriculture & Markets. Then he essentially threatened to sue the town if they did not allow farmers to use it! That's when things started to really change."

Gleason suggested that they tactfully use the leverage provided by the Agriculture & Markets license to their benefit. Thus, Waste Stream's attorneys first approach town officials who appear resistant and work to build and maintain a positive relationship with the town. The potential of a lawsuit against the town is mentioned only when absolutely necessary.

"Still, public relations are a never-ending battle," stated Gleason. " I admit that, for a while there, it seemed like we were fighting a relentless dragon. The cost of the educational programs, the licenses, the attorney's fees and the constant stress over one negative event was huge." Fortunately, Waste Streams Environmental has several other product lines. The management of Syracuse's municipal sludge may actually turn a profit during 1995, assuming

no major problems with the process and no bad publicity.

B. Land treatment of biosolids on forest lands; critical incident

A successful example of a biosolids reuse program is in Washington state's King County. Dr. Peter Machno, biosolids program manager for King County, has been working closely with the University of Washington, School of Forestry to develop an economically feasible and environmentally safe method of utilizing land treatment of biosolids in forestry applications. This program has been ongoing since 1973, and has received continuous support from the EPA in providing both technical advice and funding. Support also comes from the state of Washington, from the University of Washington and from the local county government. While some land has been purchased for the program by the wastewater authority, biosolids are also applied to privately owned forest lands, including extensive sites owned and managed by the Weyerhaeuser Company.

Machno described the many challenges the program faced in the early days. Treatment of the biosolids was never a problem as the biosolids product was treated to reduce pathogens to acceptable Class B levels, and deemed clean enough to apply to the forest area as fertilizer. However, the main technical problem that needed resolution was inventing an economical method of getting the biosolids to the forest. Until recently, the method used involved mixing the biosolids with water and utilizing an application vehicle which would spray the mixture up to 200 feet off a trail. "The results were not pretty," stated Machno, "the trees looked as though they were painted black." Also, some trees were killed by invading insects that while others became stressed due to overwatering, which suffocated the roots. This method was also costly, at $28.00 per dry ton.

A new method of applying the biosolids has evolved through Machno's research program. "Forest logging equipment has been adapted to be able to carry a manure spreader, which is able to fling the product into the forest," Machno described. "The biosolids are no longer mixed with water, but are relatively dry. It does not stick to the trees as it did before. It is blown out in flakes and falls into the leaf litter. After a month, you can't even tell it's there."

Another benefit of this new method is that the cost of application has been reduced from $28/dry ton to just $8/dry ton. "This is, by far, the cheapest alternative for disposing of biosolids, and that cost does not include the value of the fertilizer in enhancing the soil," added Machno. "Forestry application of biosolids is now heavily supported by six different environmental groups, including the Sierra Club, a very active group out here. They see it as a great public benefit, which fits nicely into the recycling trend. We are also pleased to see this process being used in other parts of the world, such as Australia and New Zealand, for example."

As with the N-Viro process, the biggest barrier the program faced was public acceptance. During the interview for this report, Machno refused to even mention the term "sludge" because he clearly did not want his program to be associated with "sludge." When asked for specifics on how the biosolids application program was promoted, Machno replied, "with 20 years of *continual* effort to educate and inform the public. With a staff of 17 people, we've spent millions of dollars on public relations." Every media channel was approached over the 20 years: the news media, newsletters, articles, attendance at hundreds of town meetings, sponsored field trips, and involvement with every academic, environmental and forestry organization. "Finally, everything seems to be coming together to result in a real success story. The support of the 503 regulations, the innovative approach in using the adapted logging trucks to apply the product, and the nation's interest in recycling were all critical components."

Innovative technologies for the production of Class A biosolids and their reuse will likely continue, with the EPA's focus on recycling and land application and with the continued evolution of communities to accept and support a biosolids reuse program.

C. The "ATAD" System, a German technology used for thermal treatment of biosolids; critical incident

"ATAD" is a sludge treatment process originally developed in Vilsbiburg, Germany. It was installed in 1977 by a man named I. Kruger, and is still in operation in Vilsiburg as well as in 35 other plants in Germany. ATAD stands for Auto-thermal Thermophilic Aerobic Digestion. Although it currently

comes with a relatively high price tag, the ATAD system can produce high quality, Class A sludge, and has some unique advantages, including a manufacturer's guarantee. The process is being marketed in the United States by James Ungerer, from North Carolina. The ATAD system has been installed at several locations in both Canada and in the United States. A plant which will use the ATAD process is currently under constructio in St. George, Utah. This installation may help to build further public acceptance for the reuse and recycling of biosolids.

St. George, Utah is a rapidly growing city of 30,000 located south of Salt Lake City. In 1988, St. George had completed a modern sewage treatment facility under the guidance of Montgomery Watson Engineers, of Salt Lake City. Lawrence Bowen, principal engineer and project manager, knew the revised federal standards for the use and disposal of biosolids were forthcoming. Since the outcome of the revision was not known in 1988, he intentionally and cautiously incorporated the least expensive biosolids disposal system into the design of the sewage plant. This would enable the city to cost-effectively adapt to the new regulations. Bowen designed a subsurface injection system for temporary disposal of sludge. This required that the town purchase about 60 acres of surrounding land and a minimal amount of specialized equipment, which could be resold if the system didn't work.

The injection system has served the community well over the past five years, with one important exception. The subsurface injection system was designed so that the nutrient load would have been absorbed by vegetation planted on the surface. However, according to Lisa Rogers, state biosolids manager for the Utah Department of Environmental Quality, the city did not plant any crops, fearing the forthcoming regulations would identify the harvested plants as "hazardous" or in some way dangerous, resulting in costly remediation mandates. Nitrogen and phosphorous, therefore, have been allowed to build up in the 60 acres.

Unfortunately, the receiving stream, the Virgin River, adjoins the site. The Virgin River contains three species of minnows listed as threatened or endangered, including the federally listed "wound finned minnow." The potential for runoff of nitrogen and phosphorous into the river and for groundwater contamination was imminent. New sludge land application

guidelines following the promulgation of Part 503 required this to be taken into consideration.

St. George was given until February 19, 1995 to come into compliance with the new regulations. The city's public works director, Lawrence Bulloch, as well as many local citizens were upset and concerned about having to put more money into their sewage treatment facility only five years after making such a large initial investment. They also felt the short time period of two years was unrealistic for their situation, which had the unusual complication of having to work around the endangered species issue. This, in combination with the nitrogen and phosphorous buildup, placed additional constraints on the sludge management guidelines the city was required to meet.

Overall, local citizens perceived that the additional precautions were "going way overboard." Bulloch's interpretation was "while we want to protect the environment and generally support EPA's decisions, we felt that our compliance levels were based on scanty data and inference, rather than on facts and research. The wastewater we discharge is probably 100 times cleaner than the receiving river, which carries a high silt load. This is all at tremendous cost to our taxpayers. It seems that a cost-benefit analysis did not take into account the economic considerations." The cost of the upgrade was $3 million. "It feels like we are under a constant effort to come into compliance, and we never quite get there," Bulloch added.

ATAD was the treatment system which was eventually selected and approved. It is more costly than many alternative systems, yet it has merit in being applied to St. George.

The *original* sewage treatment plant for St. George was in the outskirts of the city and had been completely abandoned when the new plant was installed in the late 1980's. The old plant had become a major source of odors from the sludge disposal process. The new plant was situated within 3/4 to 1 mile of an exclusive residential area. Odors and truck traffic were a definite concern to the residents. Bowen, as project manager from Montgomery Watson, took great pains to involve the local citizens throughout the decision making process. He attended many town meetings and addressed citizen concerns and fears. With his guidance, citizen committees reviewed different biosolids treatment methodologies, including innovative technologies. The choices

were limited, due, in part, self-imposed constraints. The community decided to pursue only Class A biosolids technologies, thus broadening the potential for future recycling or reuse as fertilizers. Also, the soil in this arid part of Utah is alkaline, eliminating alkaline stabilization processes. Moreover, truck traffic and odor concerns eliminated many composting and drying systems.

When Bowen heard about ATAD, he became very excited. "It met all of our constraints and most importantly, *the manufacturer included a guarantee,*" Bowen explained. "If, for any reason, Class A biosolids were not produced, *they* [Kruger] would make all necessary modifications to make it work."

The technology has apparently been used in Europe for twenty or more years, according to Bowen. The biosolids are first dewatered in a centrifuge, which reduces the volume by a factor of thirty. The dewatered biosolids then biodegrade, producing heat, in large insulated steel tanks. This kills the pathogens, effectively sterilizing the product while containing odors. Bowen believes there are a few other such facilities in Canada and perhaps two others in the United States. "Although the ATAD process is clearly more expensive," admitted Bulloch, "we agreed it was the best option, particularly with the Kruger guarantee."

Bowen added that he was particularly pleased with the support and interest the EPA regional office has shown. Bowen's impression is that the EPA probably was already familiar with the technology. Thomas Johnson, Environmental Scientist at EPA Region 8, office reviewed the proposal and readily agreed that, although the cost was high, the resulting product would produce "an excellent quality Class A biosolids, which will allow many of the biosolids disposal regulations to be met."

The ATAD system is not yet online. The initial disposal of the treated product will be through a give-away program, hopefully to local farmers. The desert environment has the potential of making the Class A by-product a valuable resource in the future. Bulloch has approached the city's solid waste landfill operation with a proposal for a joint venture for recycling. Yard waste can be composted with the Class A biosolids in a four-to-one ratio, which has greater appeal to the public and greater value as a fertilizer and soil enhancer. "Some day, the city might even be able to make a profit," explained Bowen.

Bowen concluded that although the ATAD system is going to work well, it was overpriced. "We are paying right now for the Kruger proprietary process and equipment. However, once the technology gets into the United States and becomes more established, consultants will undertake the design themselves. They'll have to be careful, of course, not to infringe on patented designs, but I predict the cost will come way down, once we don't have to pay these kinds of fees." The fees, of course, include the Kruger guarantee, probably one of the most attractive and unique features of this German technology, which is certain to be an integral component to its potential for success in the United States.

A viewpoint on sludge regulations

Dr. Terry Logan is on the Board of Directors for N-Viro International Corporation. He is an agronomist at the Ohio State University, with an environmental science background. Logan was called in as a consultant for N-Viro during the late 1980's to study the beneficial uses of the N-VIRO soil product. As stated earlier, it had already been certified by the EPA as a "Process to Further Reduce Pathogen" (or PFRP), resulting in a Class A sludge. Logan studied how this product could best be agronomically and economically utilized. The EPA's objectives for "beneficial use practices involving land application" provided the guidelines. Logan's perspectives on the barriers and incentives regarding beneficial applications of treated sludge are derived from his research for N-Viro and from his professional expertise. These are highlighted below.

The new Part 503 Standards for the Use or Disposal of Sewage Sludge will help provide new markets for manufacturers and inventors of sludge treatment processes. According to Logan, under the old regulations, there was no standard mechanism to demonstrate to managers of wastewater treatment plants that a given technology worked nor that EPA and state regulators would accept it. "The only technique available was to show the potential client a database with all the data you had collected. Data are helpful, but there were no clear guidelines to interpret what the data meant. This was similar to the kind of disclosure required for a patent. What we really needed was an EPA certification process, and that's what we got with 503."

The kinds of things required to obtain a positive equivalency determination are readily measurable parameters: pathogen kill and vector attraction. Equivalency was done through the "Pathogen Equivalency Committee" through the EPA's Office of Research &

Development in Cincinnati, OH. According to Logan, "This group was very highly qualified to do this kind of work. Farrell is a medical microbiologist. Under his direction, I felt it was a really terrific program. The Committee could require modifications in any given process. For example, N-Viro was required to increase the detention time for the sludge to twelve hours, rather than our proposed six." Logan expressed concerns that this Committee remain functional.

Logan suggested that the EPA could be more helpful in a couple of ways. First, once a process makes it way through the certification program, the EPA needs to identify, by name, the specific commercial enterprises which have obtained certification. Then EPA needs to make this list available to stakeholders upon request. "All too often, small towns make decisions without the technical guidance or expertise they should have. What small communities want is a shopping list of choices which explicitly list the technology and the producer." Logan did not accept EPA's usual defense of 'not wanting to show favoritism' and 'not recommending any processes for fear of being sued, should that technology fail.' "If a manufacturer's process has already been certified, there is no reason why, in this case, a list of EPA-certified processes cannot be provided," added Logan. "This is objective information. Our competitors [to N-VIRO] all do the job of killing pathogens. That's easy to prove. A consultant is needed when a more sophisticated analysis must be made to determine the specific cost and reliability over time."

Also,some areas of Part 503 create barriers by using vague definitions, which Logan would like to see changed. For example, the end product must reach particular levels of "stability." However,stability can be defined in many different ways. Chemical stability is far different from biological or microbiological stability. "The standards need to be direct and understandable by all stakeholders," stated Logan. "One set of criteria should be established so that inventors and manufacturers know what benchmarks need to be obtained."

Logan's final suggestion deals with the evolution of industry toward alternate management systems, which may involve partnerships and contracting out parts of the treatment process. N-Viro, for example, can be licensed directly to municipalities who may choose to publicly own and operate the entire operation. Turnkey operations can also be commissioned to licensed consultants for design and construction only. Privatization, a third option, can take many forms. Complete privatization was chosen as the preferred sludge management program for a number of municipalities in New York and New Jersey, where individual communities contract for all aspects of their sludge management. Sludge is transported and processed by the private licensee which will also distribute and market

the end product. More common are the partially contracted-out systems, such as the Syracuse, NY sewage treatment plant. Waste Streams Environment, Inc. is licensed to manage the processing of the sludge and the marketing and distribution of the N-VIRO Soil end product. There is a clear delineation of responsibility between Waste Streams Environment, Inc. and the City of Syracuse. The City of Syracuse must handle any problems which develop prior to the N-Viro processing, including metal contamination of the sludge prior to entering the treatment plant, which may result from a failure in a local industry's pretreatment system.

"Sometimes these styles of management do not fit well into the way the EPA or states have set up permits and regulations," stated Logan. "In Florida, there was no system for them to establish a sludge management permit for a private, commercial company that treated municipal waste. The EPA and state regulators need to find ways to accommodate these intermediaries and commercial enterprises. They also need to integrate into the permit the marketing and selling of the treated sludge product." With the rising cost of sludge disposal, increased interest in community recycling programs and the improved quality of sludge due to effective pretreatment programs, innovative processes which can treat sludge to produce beneficial end products will likely escalate. With such innovative processes, a variety of management systems that best meet the community's needs must be established.

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One large municipal district advocates and devises successful innovations; case studies

The County Sanitation Districts of Los Angeles County is a huge agency made up of 26 "special" districts which work cooperatively under a Joint Administration Agreement to serve the water pollution control and solid waste management needs for about 5 million people in Los Angeles county. "Special" districts are districts set up to manage utilities which are not part of a specific government entity, such as a city or county. The role of the Sanitation Districts is to provide the design, engineering, operation and maintenance of the facilities which collect, treat and dispose of sewage and industrial wastes; to provide for resource recovery (including water)**;** and to manage the solid waste program. Only the sewage treatment and water reclamation programs will be considered here.

The Districts' service area covers approximately 770 square miles and encompasses 79 cities and unincorporated territories within the county. Each district has its own Board of Directors, consisting of the presiding local mayors or officers located within that district. Each district pays its proportionate share of joint administrative costs. The Districts' overall wastewater budget for 1994-95 was approximately $333 million. Economy of size has been maintained through careful management, with the use of one administrative group and earnest support from top-management for research endeavors which continuously improve the facilities' efficiency. This support for research has been ongoing since the Districts' inception in 1923. Today, the result is one of the most economical wastewater treatment systems in the entire country, costing the average homeowner, even in this arid region, under $100.00 per year.

In the early years, the first Chief Engineer and General Manager, Albert K. Warren, was convinced that the new Districts should be based on natural topography flow patterns and not political boundaries. He organized separate districts according to their drainage basins which provided the framework for efficient management and flexibility and eliminated the need to change a district boundary when an individual city's boundaries changed. According to Anderson (1992):

> "The district agency was formed in 1923 and sustained, to this day, by people who live and breathe the ideals of engineering practice--practicality, technical innovation, quality, public service and exemplary professional conduct. They also nurtured a self-sufficiency within the organization to do its own research, planning, design, and construction management, as well as its primary function of operation, maintenance and management. It is significant that in this day, when popular culture is a far cry

> from what is was in the 1920's, the founding attributes of the Districts have been sustained. Although California, and particularly Southern California, is typically on the leading edge of cultural change, engineers and engineering continue to lead the Districts, in person and in approach." (p. 12)

Today, the agency's 1200 miles (1920 km) of main trunk sewers and 11 wastewater treatment plants convey and treat approximately 525 mgd; of this, 150 mgd are made available for reclamation and reuse. The largest facility in the Districts, the Joint Water Pollution Control Plant, is located closest to the Palos Verdes outfall pipes into the Pacific Ocean. It provides advanced primary and partial secondary treatment for 350 mgd, making this plant one of the largest treatment plants in the world.

The Districts' continued commitment to actively pursue innovative engineering practices is due, in part, to the rapid population expansion experienced in Los Angeles County and the county's need for solving problems.

> "Their self-reliance was generated by need - the rapidly expanding area was creating problems faster than solutions were being developed by the profession, and at such a scale that there were few parallels on which they could draw. A pilot plant for the Districts could easily be a full-scale facility for many of the nation's cities. Some innovations [over the years] were minor and seemingly mundane, others were evolutionary and some have revolutionized engineering practice; all first served the Districts' need. Notably, it is the only public agency to enter the American Academy of Environmental Engineers' Excellence in Environmental Engineering competition every year since the program's founding, winning prizes four out of five years." [Anderson, 1992. p. 16].

The research and development projects done through the County Sanitation Districts of Los Angeles County have included all areas relevant to a large municipality in an arid climate. Water reclamation projects were a primary focus as early as 1949. It was recognized quite early that "water was worth more than gold." Much of LA's water is imported from other states, from hundreds of miles away. Major reports and articles have been published on the topic of water reclamation and reuse from sewage and industrial waste. A water reclamation plant was piloted in 1962. During the 1970's, detailed epidemiology studies on the potential impact on human health and the environment from "reclaimed" water were completed through several universities. Funding was provided through the California Water Resources Control Board, the EPA and the U.S. Department of Health. The studies showed that the reclaimed water was virus-free and satisfied

federal and state drinking water standards. "Since our program began, a virus has never left our plant," stated Donald Avila, Assistant Information Officer at the San Jose Creek facility. "Although you could actually drink this water, we use it to indirectly recharge our groundwater basins and to provide irrigation for golf courses and a nursery. It can be used for unrestricted recreational reuse." There are eleven water reclamation plants in use today. Together, they provide a much more cost-effective means of increasing the Districts' capacity through reuse, rather than constructing more and bigger sewers. In 1991, the Sanitation Districts were awarded the Grand Prize for excellence in Environmental Engineering in Operations/ Management for their long-standing reclamation and reuse program.

Additional research topics concerning the history of the Districts include the following (dates indicate start-up; many topics continue through today, or until they are resolved): waste disposal without air pollution (starting in 1959), sludge composting (1961), aeration tank dangers (1963), centrifuging and screening of sludge (1963), nitrogen removal from wastewater (1966), mineral removal by ion exchange, reverse osmosis and electrodialysis (1970), sulfide/odor control (1973), industrial waste programs (1973), ocean disposal (1970), control of DDT and PCBs (1979), health effects of groundwater recharge (1977), sludge dewatering (1980), oxygen activated sludge (1980), forecast of effect of the CWA's proposed categorical pretreatment standards (1980), windrow composting of sludge (1980), the Carver-Greenfield Process pilot scale evaluation (1983), evaluations of protective coatings for concrete (1988) and corrosion control studies (1992).

The research topics listed above have resulted in nearly 500 publications since 1934. "The emphasis, however, is not on producing publications," explained Avila, "but on increasing the Districts' efficiency and effectiveness. Our *successes* tend to get into a report format much more readily than the unsuccessful technologies we may have studied. We have always had a long-standing commitment to encourage participation from the public and to provide information to the public." The Public Information Office in which Avila works holds an important position in building public support and consensus. Overall, public support for the Districts' wastewater and reclamation projects is positive. Occasional flare ups, such as with the Carver-Greenfield Dehydration plant, occur when there *is* a problem (perceived or real) or when the news media portray controversial projects through an unbalanced perspective.

The Districts' engineers are recognized around the country as being dedicated professionals, providing state-of-the-art research. Albert Warren, the first Chief Engineer and General Manager of the County Sanitation Districts of Los Angeles County, believed

that he owed a debt to his profession. He was instrumental in founding the Sewage and Industrial Wastes Federation, which is today's Water Environment Federation. He and a line of other district personnel have shared their experience and provided leadership through involvement in committees, publications and presentations for WEF, ASCE, APWA, AWWA, AMSA and the California Association of Sanitation Agencies. It's clear how the Districts are able to attract the best and the brightest wastewater engineers from around the country.

Ross Caballero is the current Section Head of Research for the County Sanitation Districts of Los Angeles County. Caballero agrees that the level of support for R&D given to LA County Districts is unusual among municipalities. "Only the largest municipalities seem to be able to justify the level of research we do here," stated Caballero. "I believe Chicago and New York City do comparable research, but they are managed under one municipality, unlike the way we operate. We are able to pool from a larger number of resources." Caballero's research budget is $2.5 million for the 1994-1995 fiscal year, out of a total operation and maintenance budget of $135 million.

One of the most frequently discussed barriers to innovations for wastewater treatment has been the lack of demonstration sites which can adequately test a new treatment system or process. However, the County Sanitation Districts of Los Angeles County provide demonstration sites for pilot studies for cutting edge technologies agrees that Publishing research results**,** according to Caballero, is not the central focus of his staff. "Although I certainly recognize that publishing helps others in the business, even when the results are not successful, we have constraints on our time and often cannot prioritize the production of publications. Also, I feel we are not out to crucify a vendor when a product doesn't work as expected. We really operate as a public service with the objective of finding more effective methods of wastewater treatment for *our* own site. It is local taxpayer's money, after all, that we're working with."

Under Caballero's direction, the Districts continue to perform only *applied* research. They investigate wastewater treatment processes and equipment developed internally by their own staff or brought in by vendors. There is no dedicated site within the facility for such projects**.** Rather, pilot processes are set up *in situ* at the appropriate junction within the treatment facilities. Each year, the research staff investigates several dozen projects, some taking two years or more to complete while others only two weeks. In most cases, a particular technology or treatment process is sought after in order to resolve a problem within the Los Angeles County Districts. Vendors are approached, and depending upon the situation, may be paid to pilot their product. Increasingly owever, the reverse has been

happening. Vendors are coming to the Districts' research staff to request use of their demonstration sites in order to validate their claims.

John Redner, Sewage System Superintendent for the Districts, has become a specialist in sewer pipe corrosion remedies. As discussed later in this report, cement corrosion has become one of the most urgent and costly concerns for all POTW's, including LA County. Redner has received calls from manufacturers across the U.S. pleading allow them to test their corrosion-prevention coating. "One vendor told me recently that the city of Miami will only consider their product if they've gotten the approval from *the LA County Districts,*" stated Redner. "They're starting to call it 'The Redner Test'. I've learned to be rather selective, based on what we already know, simply because we can't test everything."

At the time of this report, the Districts' research group was working on three main areas: (1) the causes and corrective action for corrosion of sewers by sulfur reducing bacteria, (2) air quality issues and odors caused by hydrogen sulfide emissions from digester gas, and (3) improved sludge dewatering and composting. The most exciting projects with large potentials for technological breakthroughs are the *In-vessel Composter* demonstration pilot plant (described in the following section) and the method of *corrosion prevention* developed by Redner's staff.

Two successful research projects are underway at the County Sanitation Districts of Los Angeles County. These are described below.

1. "In-vessel Composter" pilot plant at the Joint Water Pollution Control Plant, Carson, CA

   One of the Los Angeles County Districts' most recent research projects is the In-Vessel Composter project used for sludge (biosolids) digestion. The construction of a demonstration pilot plant at the Joint Water Pollution Control Plant **(**Joint Plant) was part of a long-term, continuing effort to find a means for cost-effective, practical and environmentally sound disposal of sludge. The Joint Plant receives and treats sludge generated by all six of the Los Angeles County Districts' treatment plants. Following an anaerobic digestion process and a dewatering process, the partially treated sludge is ready for the innovative In-Vessel Composter. At this stage, the sludge is odorous and carries human pathogens. Each day, the Joint Plant treats 1250 wet tons of

sludge cake. Odor control has always been problematic for the Joint Plant; a residential neighborhood surrounds the property.

The In-Vessel Composter uses a simple design. An enclosed "tunnel" used to increase the productivity rate of sludge decomposition and, at the same time, accommodate odor control and more stringent air regulations being promulgated from both state and federal levels. The sludge is mixed with high quality sawdust, available through many recycling programs. The Tunnel Reactor (R) system, manufactured by Simon Waste Solutions, Inc., moves materials by pushing and compressing the fresh, in-feed materials against materials already in the unit. A slight vacuum is maintained. Materials at the end of the tunnel are discharged following a detention time of 28 days. Off gases are thoroughly treated through a costly air pollution control system, resulting in air that is actually *cleaner* than the ambient air.

According to the Los Angeles County Districts' report, "The uniqueness and importance of this air management concept can not be overstated. The air management/odor control technology which was developed by the Los Angeles County Sanitation Districts takes ambient air, uses it to compost biosolids, and returns the treated exhaust air from the composter back into the environment with less air pollutants than the air originally contained." (Caballero, 1993; p. 1). Ross Caballero enthusiastically described how his staff recently "stumbled" into an experimental procedure which has shortened the composting time tremendously while controlling exhaust gases. This is done through the air recirculation system within the vessel. It was found that bacteria, as simpler forms of life, did not require high quality air. Air is used over and over again before it is extracted for the final air treatment system which removes all of the air pollutants before it is discharged. The unit cost of treating air to such high quality standards for total odor/emission control is, by far, the largest overall expense. Dramatic savings occur with the air recirculation system, resulting in a cost-effective method of composting sludge, with the advantages of total odor/emission control.

The pilot demonstration test used a full-sized Tunnel Reactor from Simon Waste Solutions, Inc., which can hold as much as 500 tons of material (500 cubic yards). The Tunnel Reactor and the air pollution equipment together cost approximately $2.1 million. Caballero calculated it would require 12 of these systems at the Joint Water Pollution Control Plant which handles

approximately 325 million gallons per day of wastewater. "While that cost is nothing to take lightly, $20 to $30 million, it still pales in comparison to the Carver-Greenfield Dehydration system, which was unbelievably complex and failed...at a cost of $166 million."

The research and development for this project was totally funded by the County Sanitation Districts of Los Angeles County. The In-vessel Composter process is being patented, and has received the 1993 National First Place Award for Outstanding Research Contributing to Enhanced Beneficial Use of Municipal Wastewater Sludge, from the EPA. Donald Avila adds, "These days, we find we *have* to patent our discoveries. If we don't, somebody else comes along and sees a great idea, then apply for the patent and we end up having to buy our technology back."

2. Corrosion control of sewer pipes: Urgency forced innovation

The huge sewer system managed by the County Sanitation Districts of Los Angeles County serves over 5 million people in approximately 770 square miles. Over 500 million gallons per day of wastewater is collected from residential, commercial and industrial sources and conveyed through 9,000 miles of sewer pipe to six wastewater treatment plants. Approximately 1,000 miles of sewer lines are owned and maintained by the Los Angeles County Districts; the remaining 8,000 miles are owned and maintained by local cities or Los Angeles county. As proponents of research with a strong service record, the Districts have maintained the sewer pipes over the years through careful management and data collection. The oldest sewer still in service is over 65 years old.

The large sewers were typically constructed of reinforced concrete pipe with no protective coatings or linings. They range in size from 54 to 144 inches in diameter. Research began in the 1930's to study the potential corrosion problem resulting from sulfides which are naturally generated in the pipes. Between the early 1970's and mid-1980's, the Los Angeles County Districts observed that the rate of sewer corrosion in their system had increased dramatically. The Districts' studies showed a high correlation between increased corrosion levels and the reduction in certain industrial wastewater pollutants. This reduction in pollutants resulted from implementation of categorical industrial pretreatment standards under the NPDES permit

program.

An EPA study in 1987 (mandated by the Water Quality Act) looked at the corrosive effects of hydrogen sulfide in wastewater collection and treatment systems and the extent of the impact of the categorical industrial pretreatment standards, which might exacerbate the corrosion problem. The Los Angeles County Districts participated in the research efforts. An EPA Report to Congress (1991) found that "although the rate and severity of corrosion varies depending on wastewater characteristics and environmental conditions, the County Sanitation Districts of Los Angeles County is the first to provide documentation of accelerated corrosion. Most municipalities have little or no documentation of corrosion problems. No entities other than the Los Angeles County Districts were found to have sufficient historical data to establish a correlation between implementation of industrial pretreatment standards and an increase in corrosion rate. Research on this relationship appears to be limited." (p. 1-2)

Despite the suspected correlation and a heavy lobbying effort by water quality professionals, the EPA did not amend the industrial categorical discharge limitations. The earlier levels of heavy metals and iron oxides from industrial discharges had inhibited the growth of bacteria which produce hydrogen sulfide gas and sulfuric acid. The categorical pretreatment standards apparently eliminated that inhibiting capability. John Redner, Sewage System Superintendent for the Los Angeles County Districts, tried to negotiate a waiver system. "We argued that the impact on POTW's of this corrosion would be incredibly high, that EPA should be careful not to take all of the toxics out, but to set them at reasonable limits which would still protect the environment. We knew that if they took them all out, there would be disastrous consequences on the concrete corrosion." In fact, sulfuric acid is produced mainly at the crown, or top of the pipe above the flow of the wastewater. This is the site of the most intense corrosion, and has caused sewer pipes to collapse.

"In a very short time, our corrosion level went through the roof," exclaimed Redner. "Nobody else had such clear evidence with pre- and post-regulations. Before the regs, we had measured corrosion at *1/4 inch over 20 years*. Now, we're seeing pipes corrode at *1/4 inch per year*! We can't keep up with the repairs that are needed as a result."

Donald Avila, Assistant Information Officer for the Districts, added, "This is one of our most costly problems right now. The cement literally turns to wet gypsum. Not only is it costly, but sewer collapses can be life-threatening disasters. We recently had a car fall into a five foot deep hole that suddenly occurred in the road beneath his car. He thought he was in an earthquake, but it turned out to be a severely corroded sewer pipe collapse."

The problem of sewer corrosion is not limited to warm climates. It is occurring throughout the United States and all around the world, wherever sewers exist and industrial discharges are regulated. Yet, many municipalities overlook the problem. Municipalities tend to consider operation and maintenance costs of the things they (and their community) *can* see and understand such as bridges, roads, landfills and schools while ignoring sewers which are underground and out of sight. However, as stated in a Los Angeles County Districts brochure about corrosion, "The truth of the matter is, without a functioning sewer system, wastewater treatment plants are irrelevant." The corrosion problem is also aggravated by the trend during the 1960's and 70's to build regionalized wastewater treatment systems for communities, rather than small, more localized systems. Longer detention times in the sewers allow for septic conditions, thus creating more sulfide gas, and therefore, greater corrosive conditions. When pollution prevention technologies were implemented by industries, they removed all the metals, including iron, chromium and cadmium. These metals were used to readily form precipitates with the sulfide, essentially removing most from the wastewater at no cost to the treatment plant.

The urgency of the problem demanded quick solutions. The Los Angeles County Districts performed a telephone survey of major municipalities in the U.S. to determine: (1) if they were monitoring their sewers for corrosion, and (2) if so, what solutions were they using that worked. The results confirmed what Redner suspected: that very few municipalities were monitoring the problem. In fact, one city official in Arizona called Redner back several months following Redner's , claiming he had 'a bone to pick' with Redner. Following Redner's call, the city's Sanitation superintendent had his staff check the city's sewers and was shocked to find severe corrosion throughout the city's system. "I was very happy until you called. Now, I find I've got a tiger by the tail."

This story is not atypical. Redner found that although some innovative technologies were coming out of Germany and Australia, he needed to invent his own local solutions to slow down the corrosion and to work on repairs.

The County Sanitation Districts of Los Angeles County have recently spent over $40 million rehabilitating and replacing 15 miles of the most severely deteriorated sewer lines. One of the temporary "quick fixes" being used by the Los Angeles County Districts is to pour ferrous chloride back into the sewers to form precipitates with the sulfide in order to slow down the deterioration process. This quick fix is at a cost of $3 million per year to the Districts.

For the first time in the history of the Los Angeles County Sanitation Districts, the support of university research was sought to help uncover innovative solutions in a timely fashion. A "Request for Proposals" (RFP) was sent to the local technical universities in the late 1980's. Four projects were selected by the Board of Administrators and totally funded by the Districts to study different solutions to corrosion. The University of Southern California compared the effect of caustic sprays inside the sewers to that of a pure water spray. USC also performed a virus study. Cal-Tech studied exotic chemicals for control of the bacteria and ultrasonic irradiation systems. UCLA studied the bottom slime layer, and the University of Arizona studied control of bacteria through microbial competition. Unfortunately, none of these projects resulted in a feasible, cost-effective solution. In retrospect, Redner feels he should have opened the RFP to the entire country in order to obtain the very best ideas and not have limited the research to local universities. "There are some really great things going on at Duke, RPI and Notre Dame," Redner stated. "The Board wanted us to stay local, since our funding was based on local tax dollars. They're right, there are plenty of good technical brains in southern California. But the problem is big enough that we need the best solution out there."

Necessity is the mother of invention. With the assistance of Ross Caballero, Redner and his staff developed an experimental system to spray the crowns (above water portions) of the sewer pipes with a caustic solution. The "crown spray delivery system" is a device which can be floated on a pontoon inside the sewers, without taking the line out of service. A vacuum tank truck with a chemical pump is connected by a high pressure hose to the floating

pontoon. The pontoon carries a spray head with a series of nozzles which are able to spray the solution at desired pressure to achieve complete coverage. The delivery system is pulled through the sewer from one manhole to another by using a cable winch. The speed and pumping rate can be closely controlled to regulate the rate of application.

Redner has experimented with many solutions. The hypothesis was that raising the sewer crown pH would neutralize the sulfuric acid formed by the sulfur-oxidizing bacteria, thus inactivating and possibly destroying these bacteria and limiting the formation of new colonies. In June 1989, Redner's employees experimented with different concentrations of several caustics: sodium hydroxide, tri-sodium phosphate, sodium carbonate, sodium bicarbonate and potassium carbonate. While all of these worked to some extent, they were extremely dangerous to handle for both employees and to the public. Additionally, the caustic spray only lasted 30 to 60 days, and then required reapplication. Under optimal conditions, a crew can spray one mile of sewer per day. Logistically, the Districts needed to find a commercially available chemical that would last longer and be less caustic.

"That's when we came up with the idea of Milk of Magnesia, the same stuff for upset stomachs." Redner said. "It's really magnesium hydroxide. We can buy it in bulk in a couple of different forms, which we are experimenting with to find the best form. But, so far, it seems to work well. It coats the pipes, just like it would your stomach, neutralizes the acid and seems to last for 9 to 12 months." This chemical is, of course, also not dangerous to handle or use in public places, and it seems to provide the buffering that is needed. "This is a very promising discovery," stated Caballero. "We have great hope of regaining control of our corrosion problem in a realistic way."

Other solutions to the corrosion problem include complete replacement (which would be the highest cost and most disruption) or various methods of rehabilitation. Rehabilitation must be done with large sewers that cannot be taken out of use. It might involve insertion of a polyethylene or fiberglass slip liner and it's very expensive. Rehabilitation might also involve the application of a protective coating for the pipes so they will not be affected by the exposure to sulfides and sulfuric acid.

Redner has been involved in testing and evaluating different coatings from

manufacturers from all over the country. He writes, "Unfortunately, too much reliance is placed on the sales representative in deciding which materials to recommend for a given situation. Evaluations of the performance of these coating systems in actual applications is not available." (Redner, 1995, p.4). Thus, Redner uses a simple onsite evaluation, where he can test five different coatings at any given time. Evaluations are conducted in shallow concrete sections of sewer pipe, turned on end so that they can hold water. The manufacturer is given 48 hours to apply the coating to the inside of the sewer pipe. Before the coating is applied, the pipe is prepared to simulate real conditions. The bottom half of the pipe has previously been exposed to a 10% solution of sulfuric acid to replicate the corrosion of the sewers. "It's not really scientific, but more anecdotal," admits Redner. "But it serves our purpose. To date, I have evaluated around 80 coatings, and they have almost all failed."

Of the 71 coatings and liners the Districts have tested, only 19 have proven successful. One involves an interesting story of a local, innovative company which wouldn't give up. The local company, now called named Linabond Inc.**,** wanted to test a polyurethane coating. However, Redner did not want to test it because he had already seen plenty of failures with polyurethane products. But, since it was a local company and a test site was available, he relented. As expected, the coating showed signs of failure almost immediately. The company's inventors went away, but came back in a few days with an exciting new approach. The polyurethane the company had produced was very sticky. They proposed to use the substance as a kind of glue for a sheet of PVC to be applied to the interior of the pipes. It was already known that PVC pipes do not corrode when exposed sulfuric acid. Redner was very intrigued. Pilot tests were successful. The Sanitation Districts of Los Angeles County now uses this product almost exclusively for their rehabilitation work. This innovative company is presently trying to market their product to rehabilitate sewers across the U.S.

This product's development provides valuable insight into the needs of successful entrepreneurs. The pilot study was done virtually for free, right at the Los Angeles County district site in Compton, California. In addition to the availablity of a credible testing site, what was needed to get started was availability of a credible testing sight, a creative idea from the inventors and an open mind from the testing authority.

In conclusion, Redner would like to see the EPA offer funding for construction, such as under the earlier I/A program, *or* funding for research. He is certain that agencies around the country are not monitoring their sewer infrastructure which is likely to be in serious disrepair. "The EPA needs to focus funding on this important need. They should be aware that there is no one "silver bullet" which will solve the problem of corrosion." Furthermore, Redner feels that a significant problem exists in this country with the fragmentation of research projects, particularly in institutions where publishing is not a priority. Research consortiums such as the Water Environment Research Federation (WERF) are invaluable players in providing such support. These are the concerns the EPA could address by increasing its support for innovation. Redner feels that if funding were available again, the Los Angeles County Districts would certainly be amenable to applying for a shared research project on sewer corrosion or any other 'hot' topic impacting the LA County Districts in the future.

A viewpoint from the head of research for the Sanitation Districts of Los Angeles County

Ross Caballero has been the Section Head of Research for the Los Angeles County Sanitation Districts since the late 1960s. He has been involved in of many research projects, has published numerous papers and given presentations at professional conferences. Like all public officials, Caballero is concerned about the current financial status to support his group and the potential for budget cuts. While he has always received excellent support for his research operations, budgets have been tightening everywhere. In the past, the EPA provided subsidies for many important research projects. However, funding stopped in the 1980s when the political climate changed. Since then, very little funding has been forthcoming from the EPA. "I remember funding for improved sludge dewatering when EPA was first formed in the 1970's," Caballero described. "There seemed to be lots of money then. But somewhere around 1981 to 1983, the funding from the federal government ceased. To my knowledge, we did not take on any new federal research programs after 1981." Since that time, most, if not all of the research projects taken on by the LA County Districts, have been funded internally.

Caballero notes there are distinct advantages to *not* having to work under EPA research grants. Caballero explained:

> "We don't use EPA as a research funding source anymore. Not having to work within the EPA required guidelines for research and to gather detailed data according to their specifications allows us to maneuver faster. For example, when we try something out and it is clearly unsuccessful early on, we simply move on to another project or set about to find modifications. We don't care why it didn't perform. We only want to find ways to correct the problem, or 'bag' it. If, however, we are working under EPA funding, we must do a complete evaluation of the failures and the successes. Each research project must have a closure and be prepared in a formal written report for technology transfer. The format for these reports is not the same as ours is internally, so it must be prepared twice, although that's really more of a nuisance than anything else."

Yet, Caballero agrees that technology transfer is an essential component when accepting funding from the federal government. He is well aware of the barriers in obtaining information related to innovations in wastewater treatment, and the value of failures as well as successes.

Caballero and his superiors are not closed to EPA funded research in the future. He would like to see some continued use of federal funding for particular research projects with broad or urgent appeal, such as the corrosion of sewer pipes. Funding could perhaps be allocated to assist in the added expense of data collection and report writing which is expected. Currently, their is little emphasis on producing the kinds of publications he and his staff used to generate. Publishing is more of a professional pride thing. We get to it when we can, but we have to be practical about our time demands first," stated Caballero. As in many fields, a great deal of knowledge and experience stays with individuals heads, and is not commonly shared with others in the water quality profession.

When asked if his facility could support demonstration projects for vendors which might not be testing technology that is directly beneficial to the LA County treatment facility, there was some hesitation. Lack of adequate demonstration sites is seen as one of the primary barriers to innovative technologies. Even in a cost-recovery or charge-back system, conflicts could easily arise. Restrictions caused by neighborhood residents who are very sensitive to noise, odors and potential exposures to hazardous materials as well as restrictions created by air pollution mandates limit the potential for demonstration sites. There might also be concerns over conflict of interest if the public perceives the Sanitation Districts agency as using public funds to test and endorse private products. Some of their concerns parallel those of the EPA regarding endorsement.

Two potential obstacles to innovative technologies were outlined by Caballero. The first obstacle is the ramifications of the Clean Air Act Amendments which are more stringent in California and especially in Los Angeles. Each industry is rated and mandated to have a very high removal of pollutants from their air emissions. Municipal sewage treatment plants have always had a problem with odors and a small amount of VOC emissions. They must contain their emissions like other industries. This added layer of regulations places tremendous costs on the municipality. For example, the In-Vessel Composting system has proven to be a costly air purification system. "There are so many other things they could look at, making a much better use of taxpayers' dollars," added Caballero. The second obstacle to innovative technologies is negative publicity which reduces public support. Secondly, Caballero has seen a change in the Districts' public relations and with the coverage of the press. "I work for a public agency and I have to be sensitive to the community," stated Caballero. "Twenty years ago, we were seen as the 'good guys'. Now we are the 'bad guys' because of the new Clean Air Act mandates and the failed Carver-Greenfield Dehydration plant, both of which have attracted media and public attention. This kind of thing infuriates the public, and could erode our research program very rapidly," Caballero said. Community perception plays a strong role in county actions; in another earlier case, Caballero witnessed a community protest during a public hearing which announced some changes to one of the treatment facilities. A group of Afro-Americans and Hispanics perceived this as a case of environmental racism and injustice, although there was no connection.

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Personal communication and interviews:

At the County Sanitation Districts of Los Angeles County, Whittier, Carson and Compton, CA. May 25-26, 1995:

Donald Avila, Assistant Public Information Officer. Information Services Section, Whittier Plant. (310) 699-7411 ext. 2304.

Ross Caballero, Director of Research. Joint Water Pollution Control Plant, Carson, CA. (310) 830-2400.

Daniel Gary, Civil Engineer. Joint Water Pollution Control Plant, Carson, CA. (310) 830-2400.

John Redner, Sewage System Superintendent. Compton Field Office, Compton, CA. (213) 774-7272.

The Solar Aquatics system surmounted state permit barriers; case study

The Solar Aquatics system for wastewater treatment is a patented process which utilizes the natural capabilities of a complex of biological organisms in an artificially created wetland to digest and treat sewage and septage. The system was researched and developed by Dr. John Todd, currently the director of Ocean Arcs International of Falmouth, MA (Ocean Arcs). This biologically engineered system consists of a series of translucent treatment tanks and a constructed marsh or wetland which create increasingly complex aquatic ecosystems. According to Todd, "This system duplicates the natural purifying processes of fresh water streams, meadows and wetlands." In colder climates, the system must be placed under a commercial sized greenhouse in order to obtain adequate year round treatment.

Ocean Arcs is a non-profit organization, the research efforts of which focus on developing natural treatment technologies for wastewater, mainly using artificially created wetlands. Todd generically calls these natural systems "Living Machines" to emphasize their dynamic nature. Solar Aquatics was one of Ocean Arcs' their first designs.

Ocean Arcs is frequently supported through government grants and research foundation monies. Congressional add-ons to EPA's budget in FYs92-95 have provided 5.75 million to demonstrate second generation designs of Natural "Living Machine" technology at four separate projects across the U.S. EPA's grantee, the Massachusetts Foundation for Excellence in Marine and Polymer Sciences (MFEMPS) has subcontracted with Ocean Arcs to carry out much of the effort to demonstrate the capabilities of these projects. Ocean Arcs, however, is not involved in the commercialization phase of the organization's research. In 1988, a new company, called *Ecological Engineering Associates (EEA)*, was formed to market and commercialize the Solar Aquatics system. This private *for-profit* firm, located in Marion, Massachusetts, exclusively owns the patent for the Solar Aquatics system. Susan Peterson, former business associate of Todd, is currently president of EEA.

When EEA was formed, the company worked with several small scale pilot projects to collect data and demonstrate the Solar Aquatics process in different settings. Although most of these pilots are no longer operating, a great deal of scientific data were collected from the pilot sites, particularly the one in Harwich, Massachusetts. Each provided valuable data which have been used extensively by EEA to market the Solar Aquatics system around the world. Peterson was pleased to announce during a recent interview

that five sites using Solar Aquatics have been completed, seven new sites are under construction and one in Canada has just been approved. Equally important, all were approved with greatly reduced approval procedures, as compared to the original pilot project which was done in the state of Massachusetts. Peterson has found that working under the constraints of a public municipality (vs. private industry) has been very challenging. She described the difficult, lengthy approval process she experienced in obtaining the first permit for the Solar Aquatics system in Harwich, Massachusetts was the first pilot project which demonstrated the Solar Aquatics system on a large scale. Many involved in the project expressed concern over the fiscal barriers experienced by EEA during the lengthy approval process in the state of Massachusetts. "In comparison to other states and other countries, like Canada and Mexico, the lengthy approval process (in the U.S.) is out of proportion," stated Peterson. It took three years and cost EEA $2.5 million. Michael Giggey, Sanitary Engineer for Wright-Pierce Engineering, was hired to perform an independent review of the data. He stated, "The cost EEA was required to bear would have forced most entrepreneurs out of business, clearly a barrier for most inventors of innovative technologies." Peterson and Todd agreed that *if* the $2.5 million cost could be removed or reduced, then grants from the federal government might not be needed (or even *wanted*) to get innovations going. Moreover, it was felt that private investors are extremely hesitant to invest in new technologies when entry costs are so high.

Peterson certainly views rigorous testing during pilot projects for new technologies as an essential component in providing adequate quality assurance and quality control (QA/QC). However, the requirements in Massachusetts were, in her words "unreasonable." "Much of this," she added, "had to do with personalities, styles and expectations, resulting in many confrontational meetings." This project was also administered by the enforcement group within the Massachusetts' Department of Environmental Protection (DEP). Peterson believed that in 1988, when this project was first proposed, DEP was not prepared to work with an innovative system which used biological treatment methods rather than more conventional methods.

Obtaining patents was also a barrier for EEA. Peterson described the high cost and the length of time in obtaining two patents for the Solar Aquatics system in the United States. The patents were applied for in 1988 and received in 1993. Application fees, filing fees and maintenance fees added up to over $100,000 during 1994 alone.

The history of the Harwich Septage Treatment Pilot Plant,

Harwich, MA

Solar Aquatics was first piloted in Harwich, MA on Cape Cod for the treatment of septage, the more concentrated sludge which is removed from septic tanks when they are cleaned. According to a journal article published by Teal and Peterson (1993):

> "Septage is harder to treat than sewage sludge because the more readily degradable organic materials have decomposed during the two to five years between cleanings. Thus, the resistant organic compounds and heavy metals concentrate at relatively higher levels." (p. 34)

The existance of septage along with the fragile ecosystem on Cape Cod, may have contributed to what has been perceived as an extremely conservative attitude by Massachusetts public officials and**,** therefore**,** the stringent review process EEA claims to have experienced with the Massachusetts Department of Environmental Protection (DEP). According to Peterson and Paula Champagne, Harwich's Health Officer and avid supporter of the Solar Aquatics system, the experience at Harwich served to initiate a regulatory pathway for those proposing innovative technologies which use natural, biological systems for wastewater treatment in the state of Massachusetts. Prior to EEA's experience, there was no review system established for new [biological] technologies. Champagne agreed with EEA's perspective, describing the "many, many barriers, both legal and institutional" in obtaining permission to operate the pilot project and in the collection of data.

The pilot project at Harwich was initially proposed in 1988, following a consent order by the state of Massachusetts for Harwich to clean up its undersized and ineffective wastewater treatment lagoon. Champagne had just been appointed Health Officer for Harwich. She noted the towns around Harwich had recently gone through the same process but found that the financial support they had received through the earlier Construction Grant program was no longer available. In addition, local papers were filled with stories of costly sewage treatment plants that had failed or that were over-designed and required the sewage of six towns in order to be cost-effective. Additionally, there were reports of chemical spills at these new plants which affected the Cape's fragile groundwater supply. About this time, Champagne read about the Solar Aquatics system and invited the inventors (Todd and Peterson) to speak to the town board. The presentation demonstrated the use of this natural, biological system, capable of treating sewage which assumably could be adapted for septage. The aquatic plants used in the system would consist mainly of water hyacinths and willows as the "work horses." Yet, with the enclosed greenhouse, many exotics and ornamental flowering plants, such as orchids, could be added. The result is

an aesthetically pleasing greenhouse system. The pilot plant, according to the basic EEA proposal, would cost $20,000 for a summer demonstration project during which data could be collected from the thousands of gallons of septage which would be treated through the pilot. This initial summer experimental project, however, did not include a greenhouse cover. The cost made sense to the town board, since just a proposal for *conventional* technology would cost at least $100,000. Harwich agreed to be the "first in the world" pilot for the Solar Aquatics system.

A small experimental septage treatment system was operated in Harwich from June to October 1988. It was sited at the town landfill and consisted of twenty translucent fiberglass tanks set outdoors on the sand between the existing septage lagoons. The water flowed by gravity through the first ten tanks, then into a constructed wetland filled with local sand and gravel. The effluent was then pumped into tank eleven for additional treatment through to tank number twenty, again using gravity flow. The final effluent was discharged back into the old septage lagoons (Teal & Peterson; 1991). This small pilot was apparently deemed a closed system by EEA; thus the DEP was not contacted for an operational permit. Massachusetts DEP later learned about the project through media coverage and, according to one consultant, "went absolutely ballistic." A great deal of friction was created**.** Both EEA and the town of Harwich were fined.

Following the summer of 1988, the DEP began official review and approval procedures for the Harwich pilot. According to Champagne, at the start of the approval process, the Massachusetts DEP did not have a Research & Development unit which was capable of reviewing the proposed innovative biological system. EEA staff and Champagne described how they were met initially by a very hostile regulatory group of state agency "concrete engineers" whose jobs entailed reviewing conventional wastewater technologies. "As engineers, they had difficulty understanding and supporting this biological system," stated Champagne. "It did not fit into any of their program boxes." Decisions eventually were governed by a legal department through hearings and administrative consent orders. Solar Aquatics was evaluated as if it were a full scale conventional system rather than a small pilot project demonstrating a dynamic, biological system. Peterson and Champagne stated that the DEP regulatory staff wanted to approve every "minor" change through a formal hearing. Each approval for a change would take two to three months. Peterson felt that the difficulty in making decisions could probably be attributed to the newness of the Solar Aquatics system, which was truly "breaking the mold" in forcing decisions on new issues. Such decisions were continually passed along to higher levels of authority, suggesting liability concerns at the state level. This obviously slowed down the progress of collecting data for the pilot project, and therefore the approval process, further driving up

the costs to both EEA and Harwich.

In addition to being The Massachusetts DEP was very conservative, the Massachusetts DEP was and admittedly skeptical over the long-term reliability of Solar Aquatics, particularly in the northeast, where the growing season can be less than 100 days. Besides In addition to the lengthy review process described above, DEP also required that an independent consultant be contracted to collect the data throughout the pilot project and to analyze the results. Further, a second consulting firm was ordered to review the final report. This was to ensure appropriate QA/QC. The cost of the second consultant (at the town of Harwich's expense) was close to $50,000.

EEA's promotional materials identified key professionals from the DEP staff and outside consultants who worked on the Solar Aquatics project. Many of these were contacted and interviewed for this study in order to obtain other viewpoints. One such viewpoint is from First is Arthur Screpetis, Manager of Research & Development for DEP.

Screpetis is an aquatic biologist who currently oversees approximately sixty research projects across the state of Massachusetts. He was heavily involved in the Solar Aquatics approval, almost from the start. According to Screpetis, the conservative regulations for Solar Aquatics were necessary because of the lack of any kind of long term track record which could validate the effectiveness of the system. Both Screpetis and Peterson agree that the "normal" review process in the U.S. for a new technology to prove itself takes two years, if all goes well. Typically, in the first few months of the first year, minor adjustments are made to enhance the effectiveness of any pilot project. Data must be collected throughout each season and throughout normal loading changes. The resulting accumulation of data can be tremendous; the data must be analyzed for a report. And finally, after the report is written, it must be reviewed by the regulatory agencies, which, "if you push it, " says Peterson, "may take six months to a year."

The review process for Harwich was completed in June, 1992, four years after the initial installation. Solar Aquatics finally received designation by DEP as an officially approved process which could meet effluent guidelines needed to operate in the most fragile environments, meeting Class I drinking water standards. The cost to EEA for the entire pilot project to final approval in 1992 was $2.5 million. The lengthy approval process is summarized below, highlighting comments and perspectives, some of which are conflicting, from the various stakeholders involved.

Early claims made by EEA representatives stated that the Solar Aquatics system would

use no chemicals *and* would produce no sludge. It was difficult for anyone with a sanitary engineers' background to envision any system which could treat septage waste and produce no sludge. These claims would have to be proven during careful analysis of the pilot study.

Screpetis stated that the DEP was also concerned about the cost of running Solar Aquatics over the long term. With no long term track record, there were no operation and maintenance data to demonstrate the overall cost-effectiveness of this system, assuming it *did* work. In order to be effective, the temperatures in the greenhouses must be maintained to keep the plants photosynthesizing throughout the year. Solar radiation in this part of the country was probably not sufficient, thereby requiring supplemental heat and light.

The "minor" changes described earlier by Peterson and Champagne were actually rather large adjustments, from an engineering perspective, to make this dynamic biological system function. Septage had not been previously treated before through Solar Aquatics; the earlier R&D was based on raw sewage effluent. The first design at Harwich failed right away. No pretreatment system had been included; it was thought that it was not needed. Pretreatment conventionally settles out most of the solids. The load at Harwich was too great and the system immediately clogged. The solution was to add pretreatment screening to remove the core of solids and to add an anaerobic digester. Anaerobic digesters are typically found in conventional plants. Since the pretreatment system did not, in reality, impact the functionality of the solar tanks in their treatment of wastewater, the DEP did allow it to be added. Other adjustments included reconfiguring the tanks (adding, deleting or rearranging them) and adding aeration to the system. While all these were logical and necessary changes in order to maximize the effectiveness of the biological system, each such change jeopardized the reliability of the data collected, which was essential to ensure a valid scientific study. With each of these added processes, the Solar Aquatics system steadily left the realm of being totally "natural and innovative" to look more like an innovative process with a great deal of conventional components needed to make it work. The cost continued to escalate.

The vastly different perspectives between EEA, the town of Harwich, and the regulatory group at DEP identifies communication barriers and perhaps educational barriers for each of the stakeholders involved. Yet, such barriers are not unusual or unexpected. As scientists and biologists anxious to see their system work, EEA wanted to adapt the system as soon as a problem became apparent. There were always ways to change this complex "living machine." The engineers wanted to collect solid facts based on a thorough

scientific study, because by design, changes cannot be made without a "ripple effect." Since the Massachusetts DEP's function is to protect human health and the environment, a conservative attitude was warranted, particularly in a fragile ecosystem such as Cape Cod. Furthermore, the consulting firm hired by the town of Harwich to review the project fully supported DEP's strict reviewing process and regulatory decisions. The Solar Aquatics treatment system needed to be validated before it could be approved for full-scale use.

Harwich's experiment has a peculiar ending. Paula Champagne described it well by stating "the pilot project was very successful but the patient died." It was previously mentioned that none of the pilot projects are currently functioning; this includes the Harwich project. In 1992, the DEP felt Sufficiently comfortable with the data collected and the knowledge gained to authorize a full scale Solar Aquatics system for Harwich. Wright-Pierce Engineering carefully reviewed the data and stood behind the system, as "one which was made to work well" given the proper conditions. Furthermore, the effluent met Class I drinking-water standards, the designation necessary for a commercial facility to operate in the most fragile environment.

Public bids went out with the intent of privatizing the treatment system. However, an unfortunate situation developed. Haulers of septage were determined to take their loads to the least expensive dumping site which, by law, is their right. Because of the large fluctuation between winter and summer populations on Cape Cod, the steady flow of septage could not be guaranteed to the haulers, and the price of treatment soared from 2-3 cents per gallon to 15-18 cents per gallon. In essence, it would be cheaper to haul the waste to Rhode Island than to treat it within the town of Harwich. Their constitutional rights would be violated if they were forced to dump at Harwich, even though that was the source of the septage. Haulers banded together and took the case to court. (During this time, parallel battles were going on over landfill operations and garbage haulers.) Harwich was forced to drop the entire project. Currently, the town uses the oversized treatment plant at Yarmouth, a neighboring town.

In retrospect, all stakeholders feel the experience with Solar Aquatics held great value, despite the problems encountered. Ecological Engineering Associates has collected strong supportive documentation and most importantly, did obtain authorization for a full scale plant in Massachusetts which is one of the most stringent states in the country. This has become a powerful marketing tool for EEA. Several new plants are in the proposal or planning stages in the United States and in Canada. (One in Ashfield, Massachusetts is discussed later in this report.)

Paula Champagne, representing the town of Harwich, stated that she feels proud to have been involved with the approval of this new technology, not only in "putting Ecological Engineering Associates on the map, but also in opening communication lines with the DEP in supporting efforts for innovative projects, which should *not* duplicate conventional reviewing procedures." The initial hostility mellowed as Harwich "stuck to their guns."

National recognition was given through the Innovations in State and Local Government Award Program of the Ford Foundation and Harvard University. By the end of the project, the climate was much more positive. The financial investment made by Harwich seemed to cover much of the cost of the two years of treatment the town received.

The Massachusetts Department of Environmental Protection has benefitted with the addition of not only this particular innovative project, but also in setting the foundation for future projects using non-conventional treatment methods, particularly biological systems. Since the Solar Aquatics experience, a more formalized process for reviewing and encouraging innovative technologies for wastewater treatment as well as for other environmental technologies has evolved. It is being coordinated with *The Center for Environmental Industry and Technology* (CEIT) program, sponsored by the EPA New England Regional Office.

Interestingly enough, the consultants at Wright-Pierce and Susan Peterson predict the same barriers will occur for Solar Aquatics if they propose it in any other environmentally conservative state. Even with all the data, EEA would probably be required to run another test pilot, with similar constraints and demands, in order to gain approval. "Demonstration sites which are scientifically designed and evaluated by an outside source are important," stated Michael Giggey, from Wright-Pierce Engineering. "However, the technology transfer is equally important. The findings must be published in peer reviewed journals, such as those at the *Water Environment Federation*. Also, it should be presented at conferences until people become more educated and comfortable with these new systems." Giggey would like the EPA to support such educational efforts and reinstate the *Technical Transfer Bulletins*. Giggey also feels fiscal support is needed for most inventors. "Most entrepreneurs simply do not have the kind of cash reserve that EEA was able to come up with. That's a major barrier right there."

Ashfield, MA gains approval for a full-sized Solar Aquatics System

Ashfield, a small municipality in the Berkshire Mountains of western Massachusetts, will have the first full scale Solar Aquatics wastewater treatment system in the United States. Ashfield obtained approval from the Massachusetts DEP in early 1995 following two years of negotiations. Ashfield was awarded grant funds in 1978 under the Construction Grant Program but it was never able to use them because of delays and changes in state regulations which prevented an earlier proposal for a conventional community septic system from being built. Thomas Leue, Ashfield's Board of Health Officer overseeing the treatment plant, began negotiating with Susan Peterson about the Solar Aquatics system in

1991, and actively pursued approval from the DEP over the next two years. Leue stayed in close contact with the Harwich project and DEP regulators. He observed the regulatory obstacles Peterson overcame and concluded "Ashfield was able to build on the Harwich pilot; they paved the way for our approval." Leue felt the two year approval process was about what he anticipated. The plant began construction in 1995.

Ashfield is an interesting case study. When built, there will be solid documentation for the Solar Aquatics system's treatment capabilities and operation and maintenance costs for a full scale plant in the northeast. There were some objections to the plant, and in fact, the town's long-term engineering firm (who requested not to be identified) concluded that the Solar Aquatics system would *not* be a cost-effective solution as compared to a more conventional system. Diane Perley agreed with the engineering firm. Perley, an environmental engineer with NYS's "Self-Help" program, has a good handle on the normal costs for the construction of sewage treatment plants for small towns, including costs for innovative projects. When she read about the Solar Aquatics proposal for Ashfield, she was astonished that it had been approved. "The costs were just astronomical," she concluded. Yet, a portion of the costs have been absorbed through the earlier construction grant and other funding sources which Ashfield received.

Following a presentation by EEA, the town took a vote. The Solar Aquatics system won by a huge margin (292 to 2), despite the projections that the system could cost 8 to 10% more than a conventional alternative. Leue described some of the significant benefits which were perceived: "In this small town, way up in the Berkshires, we thought about the more conventional concrete system and compared that to the semi-tropical environment of the greenhouse. Not only will we have an opportunity to offer an income stream through the production of exotic greenhouse plants, but we see educational value, and hope to foster a sense of pride. This could become a cultural center for our town."

The Massachusetts DEP did approve the plant for Ashfield, but with very stringent guidelines and added mandates. According to Peterson, "The plant is way over-engineered. The marsh is twice as big as it needs to be and so is the capacity of the surge tanks. An additional greenhouse was required, too. The State required redundancy at every level, multiples on top of multiples. They took the worst case analysis on *everything*."

One additional barrier were the complications and tremendous paperwork required of the town of Ashfield in obtaining grant funds. Three sources of funding were eventually used: The Construction Grant from the EPA, the Massachusetts State Revolving Fund and a

Rural Development Authority grant. When the bid for construction went out, each of these three agencies had different requirements for fulfilling their grant. The result became a costly and time-consuming managerial function which could have been avoided if the granting agencies (which are commonly used in combination) had merged together their individual requirements.

DEP has admittedly been conservative. The system is still very new and has not been tried on a full scale. Arthur Screpetis of the DEP stated that the agency's primary concern was the lack of data on long-term reliability. A secondary concern was the cost effectiveness of the operation and maintenance. Other pilot plants, such as one at the Ben and Jerry's Homemade, Inc. in Vermont, are no longer operating because they were proven to be ineffective and not economical to operate. Screpetis suspects the system at Ashfield will require the expertise of a chemist or biochemist to maintain. The DEP must continue its role in the protection of human health and the environment. Therefore, while the operational costs are the town's responsibility, the agency does not want to see this small town left with a failed system and no recourse for replacement. The outside consulting engineers which reviewed the work agreed with most of the DEP requirements; they too do not want to risk failure.

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A constructed wetland system is being piloted for a small town in upstate, New York; critical incident

John P. Regan, the Mayor of the Village of Minoa, wakes up at 2 a.m. on many dark nights worrying about the innovative project being tried at his village's wastewater treatment plant. A bedroom community of Syracuse, NY, Minoa has a population of only 3,700 people and virtually no industry to support it's tax base. The village was forced to enter into a consent order with the NYS Department of Environmental Conservation (DEC) to correct violations of its State Pollution DIscharge Elimination System (SPDES) permit. SPDES is New York's equivalent to the NPDES permit. This community has been struggling with the problems of an undersized and aging sewage collection system which was unable to handle sustained flows each spring.

"The fine hit us totally by surprise," stated Regan. "We had just completed an expensive upgrade for the system, but apparently we were still out of compliance. Nobody from the Enforcement Bureau at DEC warned us. We seriously considered dissolving the village."

The village of Minoa's history for this project is not atypical for small communities with an aging treatment plant. Moreover, Minoa is surrounded by wetlands which further complicated the problem. In 1990, the average daily dry weather flow into the village's trickling filter plant averaged 0.2 mgd, but in the spring of 1990, the plant experienced sustained flows of up to 2.0 mgd. It was under these spring flow conditions that the village was unable to meet the discharge requirements of their SPDES permit and was ,therefore, required by DEC to correct the violations. Despite better management efforts and increased spending since 1990 to reduce system infiltration and inflow, permit violations continued as a result of the village still experienced peak flows in spring that were in excess of ten times the average dry weather flow. Additionally, during the summer months of low flow, the village treatment plant often exceeded its nitrate limits. Replacement of the collection system was not affordable in this community with such a small user base and with no construction grant support.

Regan's full time occupation was with Bristol-Meyers until his recent retirement. As Mayor, he had no background in wastewater treatment and no staff engineer on whom to rely. He found he was unable to obtain technical support from Environmental Conservation (DEC). Realizing the critical nature of the consent order and the complexity of the problems with his village's sewage treatment plant, Regan resolved to immerse himself in understanding the technology of wastewater treatment. After much self-study, a bid went out. Twelve consulting firms responded. Only one firm, Clough-Harbour &

Associates of Albany, NY, offered a non-conventional, simple solution to put Minoa back into compliance. Clough-Harbour proposed a constructed wetland with subsurface flow for the treatment of combined sewage. This was, by far, the most economical choice for Minoa. The construction cost was bid at $742,000. According to Shawn H. Veltman, P.E., a partner at Clough-Harbour, Minoa would have the first artificial wetland permitted for municipal wastewater treatment in the state of New York. Veltman expected the benefits of the constructed wetland to include low costs for capital investment; operation & maintenance; and energy. Also, since no sludge would be produced, all sludge disposal costs would be eliminated.

The proposal was accepted by DEC. Eventually, with assistance from Clough-Harbour, the fine for the discharge violations was reduced from $16,000 to $9,000. Design began in January of 1994 and was completed in the fall of 1994. Construction is still underway but is on schedule to be completed during the spring of 1995.

This project entails many financial risks for the village since the technology has not been fully demonstrated. *The Clough-Harbour project description* from 1994 reports the following (section 1.1):

> "To date, much of the research that has been done and published about wetland technology is difficult if not impossible to apply in practice since the variables involved in the demonstrations were either not fully recognized or quantified. As a result, accepted engineering guides for the design of municipal wastewater treatment facilities contain little or no information on the design of these systems. Full-scale testing under controlled conditions is the only realistic way to generate the design data that are needed to reduce the risks of failure and provide engineers and regulators alike with the knowledge that is needed to fully reveal the advantages of wetlands treatment technology. Recently, the Pioneer Valley Planning Commission in Chicopee, Massachusetts began to explore the possible use of wetlands for meeting secondary treatment of combined sewage overflow treatment. However, efforts to apply the technology have been slowed by the lack of recognized design standards."

Minoa will serve as a demonstration project with potential applications for artificial wetland projects throughout the northeast where a colder climate will directly impact the treatment capabilities of the wetland. Because of the innovative nature of this project, Minoa has sparked interest among wetland experts and engineers as well as being awarded outside funding. The village will receive funding and technical support from Clough-Harbour &

Associates, the NYS Energy Research & Development Authority (NYSERDA) and Clarkson University in Potsdam NY. Moreover, a zero interest loan has been provided by the NYS Revolving Loan Fund for Water Pollution Control. However, the conditions for this loan present barriers. The loan requires substantial expenditures for research, design guidance, performance verification and technology transfer. The Environmental Technology Initiative (ETI) awarded NYSERDA and Minoa two hundred thousand dollards ($200,000) in 1995 to support the project. Environmental Technology Initiative (ETI) program has been requested.

Other barriers occurred during the project's proposal and approval stages. The design engineers at Clough-Harbour & Associates needed to expend energy and time educating and then promoting the concept to DEC. Initial DEC resistance stemmed from concerns about odors resulting from the use of wetlands to treat wastewater and from the negative effect on treatment capabilities by the cold climate in New York state. Once both of these concerns were addressed in the design, which incorporated treatment through subsurface flow, the project was given an Interim Operating Permit and has since been genuinely supported by DEC.

The Minoa project has an unusual complication involving wetland protection laws. As previously mentioned, the wastewater treatment site is surrounded by natural wetlands. In order for the constructed wetland to be approved, a 100 foot barrier was required between the constructed wetland and the natural wetland. The constructed wetland is fully lined with a polyethylene liner and contains 2 to 2.5 feet of gravel media through which the wastewater will flow. It will be artificially controlled by regulating the water levels at certain times of the year to inhibit or encourage certain kinds of wetland flora. However, use of constructed wetlands for wastewater treatment has some EPA and state wetland regulators deeply concerned and an interesting question has been raised. In future years, as these "artificial" wetlands regenerate themselves and wildlife is attracted and stays, must these artificial wetlands be classified and protected in the same way that natural wetlands are?

Of all the barriers to address, Clough-Harbour feels the most serious barrier to Minoa's wetland treatment system is the consent order's time constraints. Minoa must comply with the consent order within a one year window. Therefore, the project has been on a very tight schedule with construction beginning in the fall of 1994. However, the wetland vegetation must be planted in the spring of 1995 and will require time to grow in order to have any effect in the treating of wastewater.

"It seems," stated Veltman, "that DEC could have cut us a little more slack on the consent order. This is barely enough time to get things in place, without even considering the research reports and data collection we are required to do."

This demonstration project will enable engineers to evaluate the effect of wetlands for wastewater treatment in the northeast and develop overall construction**,** ~~and~~ operation and maintenance costs as well as energy requirement comparisons. Representatives from Clough-Harbour and Clarkson University will actively pursue technology transfer opportunities through professional publications, on-site facility tours, a seminar, and a one day workshop for government officials, engineers and regulators. Regan plans on being very proactive about the project once it has proven success.

"I envision a roadway around the site, with teachers and school buses here, running educational programs. We'll even be open to the public for bird watching," Regan enthusiastically stated.

However, as enthusiastic as he sounded, Regan wants absolutely no coverage in the Syracuse newspapers until he's confident of a successful outcome. His fears of failure are sincere. If the entire investment is lost, then the Village of Minoa *would* need to reconsider dissolving.

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"Snowfluent™": an innovative solution for cold climates; critical incident

A new application for a very old technology has been "invented" by Delta Engineering of Ottawa, Canada and is being piloted in the state of Maine. Delta Engineering specializes in the design and implementation of snow making equipment. The highly developed technology in this field is dependent on sophisticated computer models that measure the air temperature and wind speed in order to regulate the snow making apparatus to produce the best quality and quantity of artificial snow. This apparatus has been adapted for wastewater treatment utilizing a land treatment method for the Village of Carrabassett Valley near Sugarloaf Ski Resort in the state of Maine.

"Don't worry," explained Dennis Merrill, permit manager for Maine's Department of Environmental Protection, "We're not skiing on poop here."

Ski resorts have common problems when it comes to treatment of their wastewater. The peak need is in the winter when conventional methods of sewage treatment function at a lower rate. The highly fluctuating day-to-day loads raise havoc with the effectiveness of biological systems. Additionally, ski resorts are often located in environmentally sensitive areas. Many use a series of storage lagoons to hold their wastewater until warmer weather, when it can be treated through a more conventional method. When lagoons fill up, additional ones must be built. Construction of new lagoons is expensive and results in major environmental impacts on pristine mountainous areas. At Sugarloaf, the owners of the Carrabassett Valley Sanitary District who operate the ski resort's sewage treatment system were ready to try something new. Their seven lagoons were not adequate for the increased storage demands.

Jeffrey White, Delta Engineering's president, was deeply aware of wastewater treatment problems common to many ski resorts. In fact, he started researching the problem 15 years ago, utilizing his company's expertise with snow making technology and combining it with a modern understanding of sewage treatment.

"Although the technology is complicated, 'Snowfluent™' works on a simple assumption," explained White**.** "As the wastewater is sprayed out of towers in the winter, under the correct conditions of high pressure and cold temperature, the water is made to freeze instantaneously, reducing all bacteria and viruses to below detectable levels. The frozen 'Snowfluent™' as we call it, is sprayed out of special nozzles located on towers in remote areas that are 30 feet in the air. This intentionally builds up in large piles of a dry packed

ice crystals which will melt rather slowly. Given the proper soil conditions, the melt water is absorbed slowly during the warmer months, and may not be completed until mid-July. In the end, the only indication of the 'snow' pile is a white residue on the surface of the ground. This residue contains phosphates and other precipitated salts in very low concentrations, similar to a low grade fertilizer. It won't dissolve in water, but will be absorbed by plants, given some time."

White reports that this system functions well in cold climates. It can be combined with traditional treatment systems to form a hybrid process capable of operating in any location which has at least some freezing temperatures in winter. These hybrid systems are often smaller in size and cheaper to operate than a system designed around only a single process. Additionally, Snowfluent™ uses no chemicals for the disinfection process. Environmental studies verified that the ice crystals produced in the Snowfluent™ are devoid of bacteria and even the most viable viruses. There are no toxic residues left after disinfection.

Delta Engineering describes the process as a simple, forgiving one, resulting in a very economical treatment system as compared to any conventional method. In the case of Carrabassett Valley, consulting engineers were hired to separately evaluate the Snowfluent™ process. Woodward & Curran, engineering consultants from Portland, Maine, estimated that the direct operating costs (labor, energy, maintenance, consumables, laboratory tests and incidental costs) support Delta Engineering's claims. According to this study, for each 1,000 US gallons of wastewater treatment, the Snowfluent™ method cost is estimated at $.40 to $.90, as opposed to secondary treatment, which is $1.75 to $3.50 per 1000 gallons, and tertiary treatment which is estimated at $3.50 to $5.50 per 1000 gallons (White & Frere, 1994). [It has been noted by Robert Bastian, EPA, however that this study may be comparing the cost of add-on technology to existing facilities to the total cost of more conventional approaches for secondary and advanced treatment.] The Snowfluent™ process at Carrabassett has the potential to more than double the capacity of the existing lagoons. Preliminary estimates show that the Snowfluent™ system will cost approximately half of the capital cost of adding lagoons and spray areas (Warren & Marston, 1994). Process to be between $1.5M - $2.8M to expand the lagoons.

Delta Engineering had 12 years of detailed research and could back their claims with positive pilot experiences in Canada. The favorable impact on land use would result in long-term cost savings. The Carrabassett Valley Sanitary District was sold on the process and applied for a modification of their Waste Discharge License (Maine's NPDES permit

equivalent) to allow the addition of the Snowfluent™ process to their existing treatment/disposal facilities. An Experimental Permit was required during the first trial year of operation (1994). Moreover, Carrabassett Valley Sanitary District has secured financing from FmHA and the Maine Department of Environmental Protection's (DEP) State Revolving Fund in the amount of $300,000 to cover the cost of construction, which was done during the summer of 1994. Delta Engineering did not experience any permitting barriers with Maine's Waste Discharge License but there were some slowdowns due to concerns voiced from the DEP which had to be addressed.

"There is some risk with the Snowfluent™ process," said Dennis Merrill**.** from the DEP Permitting Department. "If you don't have the exact right combination of soil percolation or have a large enough remote area where this can take place, it won't follow the cost-effective model that Delta Engineering established. But assuming the right soil conditions are used in the right area, we have concerns about the absorption capabilities during spring runoff. I support the project, in general, and I'd like to see it succeed. We will be monitoring carefully during the next few years."

In Carrabassett, The 'Snowfluent' spray site is in a remote area away from the skiers and the soil has good percolation. However, Merrill is still concerned about the surface runoff in the spring. This system provides such careful control over the *buildup* of the Snowfluent™pile in the winter but there is no control over how *fast* the 'Snowfluent' will melt in the spring. Delta Engineering states it will take 120 days to melt, through about mid-June, but it could melt faster. This could result in ground saturation, which might also end up contaminating the groundwater. Also, this site is located in an important lake basin which the DEP needs to protect, and which will be watched closely during the first years of operation.

Outside of this minor slowdown (or "hoop to jump through", as Jeff White said) Delta Engineering claims they did not experience permitting barriers in Maine. Considering, however, that the research and development for this invention really began 15 years ago, time factors certainly do become a serious barrier for a business venture. Fortunately, Delta Engineering's main business was in snow making. The Snowfluent™ process was not critical to its survival. If it were, it is unlikely that this product could have endure the overhead expenses needed to become successfully commercialized. In 1995, Delta Engineering was honored with Popular Science Magazine's "Best New Ideas" Award.

Currently, the Snowfluent™ project is the only innovative project the DEP is aware of in the entire state of Maine. In comparison, Maine did support many innovative or alternative

technologies under the Construction Grant program. The state of Maine had 100% utilization of it's Innovative/Alternative incentive monies during 1979-1985, with 15 innovative projects and 22 alternative ones. As stated earlier, this suggests that the interest in innovative technology is low when grant money is not available.

It should also be noted that Snowfluent™ has not yet been fully permitted in Canada, although the Ontario Ministry of the Environment and Energy (O.M.E.E.) Southwest region completed a joint experimental project with Delta Engineering and reported positive results. The O.M.E.E. does seem to support Snowfluent. According to White, internal conflicts along with other pressing priorities have made communication among the various permitting offices in Canada very difficult. [Also note: This is the *opposite* experience encountered by the Massachusetts company, Ecological Engineering Associates with their Solar Aquatics artificial wetland technology. EEA found nothing but barriers in the U.S. and tremendous support and rapid approval in Canada.]

According to White, "The Ontario Ministry on the Environment and Energy *has* stated that Snowfluent™ is many times more effective in the treatment of wastewater than any other process being approved today. Although Carrabassett Valley is the first full scale demonstration project in the world, we've used our technology in Canada under an emergency situation, where a lagoon was overflowing and we had, by far, the cheapest and quickest remedy."

In this emergency situation, Bruce Industrial Park in Tiverton, Ontario had an overloaded treatment plant. The alternatives were to either shut down the industrial park, discharge the wastewater into Lake Huron or treat it using Delta Engineering's Snowfluent™ process. In excess of 60,000 cubic meters of wastewater needed to be processed. A Certificate of Approval was granted by O.M.E.E. for a temporary Snowfluent™ facility. Very stringent requirements for levels of treatment were included. Additional testing confirmed the findings of earlier tests, that "no detectable difference was measured between waters entering and leaving the site." (White & Frere, p. 12)

The slow permitting process in some states, the mind set, and the public's perception can all play important roles in slowing down the innovative wheel to a near stand-still. In fact, during a telephone interview, a permit writer in Vermont initially confused Delta Engineering's Snowfluent™ product with one of its competitors on a project in Killington, VT, which was surrounded by very negative publicity. Ten to fifteen years ago, the competitor proposed to use a similar spray technology to dispose of wastewater, but using <u>treated</u> effluent. The purpose, in that case, was to increase the capacity of the lagoons

during the winter and *also* to make snow on the ski slopes. Under the proposal, people would have been exposed to the effluents, albeit, treated effluents. There was a public outcry; people did have the vision of 'skiing on poop.' The Vermont Department of Environmental Protection refused to permit it. This story, now approximately 15 years old, has created a negative connotation for the technology. It has the potential to rub off on similar innovative projects, such as this one invented by Delta Engineering, causing endless P.R. barriers and additional expense to overcome people's misconceptions and reeducate them.

Delta Engineering has recently had several inquiries about the Snowfluent™ process from New Hampshire, Vermont, New York and Massachusetts. A seminar was held in February, 1995 at Carrabasset Valley so that interested parties could see the process first-hand. Given the correct setting and solid data collection which verifies Delta Engineering's claims, Snowfluent™ may take off very soon with this Canadian product actually gaining acceptance in the United States before being fully accepted in Canada.

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Ultra-violet disinfection systems; critical incidents

In the United States and in Canada, the use of ultra-violet (UV) disinfectant systems has become a widely accepted practice in the treatment of municipal wastewater. As a substitute for chlorination, UV has some definite advantages and has proven to be as effective when using the "second generation" (or later developed) UV technologies. According to O. Karl Scheible, UV expert at Hydroqual in Mahwah, NJ, "UV has become a ringing success for effluent disinfection. It is now well accepted after being validated through a number of studies and research reports." Scheible has developed a national reputation from his research on the use of UV as a disinfectant. Much of this research was funded by the EPA under an initiative to look at alternatives to chlorine disinfection. UV was placed in the forefront; it had already been used successfully in Canada. The research culminated in the production of a design manual: *Municipal Wastewater Disinfection Manual*, EPA, 1986. One entire chapter is dedicated to the use of UV for disinfection.

The success of UV as an accepted practice for disinfection is shown by the growing number of municipal plants using UV. According to Scheible, in 1984, when UV systems were seen as truly innovative technologies in the United States, there were approximately 50 operational systems. In 1990, there were approximately 500 UV systems, and by 1995, 2,000. Bruce Lawler is a marketing agent for Bailey-Fischer & Porter, a manufacturer of wastewater instruments. UV equipment is one of their major product lines. Scheible and Lawler agree that the rapid acceptance of UV can be attributed, at least in part, by the strong support demonstrated by the EPA in the funding of research efforts and the production of the well-known EPA design manual on disinfection (mentioned above). "When EPA wants to put money into a research project, others listen, developers [consultants and manufacturers] respond," stated Scheible, "EPA holds a lot of sway. These products are now deemed technically sound." Lawler added, *"While this is a technology that would have 'sold itself' based on its solid advantages and capabilities, it seems clear that it happened much faster because of the support people perceived from EPA."* This support from the EPA, then, was viewed by the industry as a "U.S. EPA approved technology" even though the EPA has made it clear it is NOT in the business of reviewing and approving innovative technologies. "Still," stated Lawler, "if more funding were available for similar studies of technologies which appear to have great promise for success, more innovative technologies would be developed more quickly."

The simultaneous increase in the number of states enacting stricter regulations regarding the use of chlorination also heightened the interest of this alternate form of disinfection in a relatively short period of time (i.e., *new regulations drove the innovative technology*). Chlorination systems use chlorine gas, a highly poisonous gas for workers to handle and have onsite. There has also been a growing concern about the unwanted chlorine byproducts which could be released into the receiving body of water along with the treated effluent. Thus, many states, such as New Jersey, began regulating the use and handling of chlorine. William Fehrman, disinfection products specialist of Bailey-Fischer & Porter, feels that New Jersey has gone way overboard with its chlorine regulations. "If it weren't for the new regs," stated Fehrman, "chlorination would be much cheaper and easier to use. Some places are requiring effluent discharges of zero percent chlorine in the outfall pipe. This is definitely the driving force on UV

UV systems were first developed in Canada. Trojan, a Canadian company, received strong Canadian government support which funded research to validate the ability of UV to disinfect wastewater. The United States followed this research and, in 1978, the EPA funded its own research to look for alternatives to chlorination. Demonstration and testing was done by Hydroqual in Bergen, NJ and in New York City in 1980. The research demonstrated that UV disinfectant systems have definite merit and are easily applied to municipal wastewater treatment plants. However, the earlier systems were not well understood by the industry and initially not well accepted.

These "first generation" systems performed well under conditions where the influent was of good quality, with low suspended solids. Yet, the technology's capabilities were limited due to a faulty hydraulic design and ballasting problems. Unfortunately, a group of small start-up companies sprung up in the New England states, hoping to make quick profits on the new UV technology using the first generation design. The technology's reputation plunged, as these small companies misapplied the information in the design manual and did not support the installations they had completed. In fact, the state of Maine stopped permitting UV systems. Fortunately, further studies in the late 1980's improved the hydraulic design allowing UV to become equally effective as chlorination for disinfection. The equipment is manufactured by several large, competitive companies in the United States and in Canada, many of which have patented UV disinfectant equipment for wastewater treatment. "A third generation design is now underway." explained Scheible, "Now we just want to make minor adjustments to 'tweak' the technology to become a bit more efficient, and gain advantage over our competitors. We've gotten to the point, however, where we are as cost-effective as chlorination, and that's a big step." What must be taken into consideration however, are the additional utility costs for electricity in using

UV. "The advantages [of UV] now far outweigh chlorination when you also consider the negative effects of chlorine on the water quality, and safety issues which are associated with chlorine," concluded Scheible.

A new manual on disinfection is being sponsored by the Water Environment Federation. This manual is a comparative study of the efficiency of chlorination-dechlorination and UV irradiation, and will serve to update this important technology, taking into consideration the new regulations. With over 2,000 applications, UV can no longer be considered "innovative."

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O. Karl Scheible, Civil Engineer. UV Research Expert, Hydroqual, Mahwah, NJ. (201) 529-5151.

6. Initiatives Which Support and Encourage Innovative Technologies

At the start of this research project, it was assumed that successful programs which support innovative technologies for wastewater treatment were in existence, and at various stages of maturation. Technology developers and manufacturers have found various doors and windows to successfully commercialize their products. A growing number of initiatives from both the private and public sectors provide the means by which barriers discussed throughout this report are being broken down. The descriptions which follow highlight some of those programs.

The Environmental Technology Initiative (ETI)

In his first State of the Union address on February 17, 1993, President Clinton outlined a new Environmental Technology Initiative (ETI) to accelerate environmental protection, strengthen America's industrial base, and increase exports of U.S. technologies and expertise. Congress appropriated more than $100 million for ETI in FY1994 and FY1995, which was used to fund over 250 projects in several major ETI program areas.

One of the primary thrusts of the ETI is to adapt EPA's policy, regulatory, and compliance framework to be more friendly towards innovative technology. EPA recognizes that unlike other consumer markets, the market for environmental goods and services in the U.S. is largely driven by the environmental policy framework that EPA administers. American businesses spend over $130 billion a year to comply with federal environmental mandates. But environmental laws and regulations often hinder technology innovation by making it difficult or undesirable for polluters to use -- and consequently for vendors to market - - new control technologies. As a result, the pace of technology innovation in the U.S. environmental industry has lagged. As the primary agency responsible for administering the U.S. environmental policy framework, EPA is in a unique position to lead other federal, state and local agencies in an effort to reduce barriers to, and increase incentives for, innovation while ensuring that environmental protection is not compromised.

Policy, regulatory and compliance barriers to technology innovation can take many forms. For example, most environmental standards that are currently in place serve to "lock-in" the use of existing technologies because they are based on technologies that were already well-demonstrated when the standards were promulgated. Even when companies are legally permitted to use alternative methods to meet a standard, they are usually unwilling to risk non-compliance by implementing a relatively unknown or unproven technology. Enforcement personnel do not normally grant exceptions for businesses that make bona fide attempts to comply using an innovative approach but need extra time or fall short of

the regulatory mark. Since companies are given no reward for trying something new and no protection against failure, the same old technologies are used over and over again, year after year, freezing out newer and more effective options.

ETI is working to eliminating major policy, regulatory, and compliance barriers by increasing incentives for innovation and providing more flexibility to implement better environmental solutions. For example, ETI's Reinvention for Innovative Technologies (ReFIT) program, being implemented by the Office of Policy, Planning and Evaluation, is currently advancing over 40 projects designed to eliminate barriers to technology innovation in the regulatory process. These include:

- Helping local communities overcome regulatory barriers to the use of innovative wastewater treatment technologies, such as constructed wetlands, to meet state water quality standards.
- Exploring ways to give plant managers in the pulp and paper industry the flexibility to achieve compliance using methods they choose.
- Working with states and industries to develop flexible air emission permits that can accommodate rapid changes in the manufacturing process without sacrificing air quality goals.
- Employing workshops, focus groups, and interviews with stakeholders to find ways to enhance incentives for pollution prevention.
- Exploring the benefits of flexible, multi-media permitting for the iron and steel industry.
- Developing ways to encourage interstate cooperation in permitting new technologies.

The Environmental Technology Verification Program (ETV)

Another major thrust of the ETI is to strengthen the capacity of technology developers and users to succeed in environmental technology innovation. Throughout its history, EPA has evaluated technologies to determine their effectiveness in preventing, controlling, and cleaning up pollution. ETI's Environmental Technology Verification Program (ETV), being implemented by the Office of Research and Development, is now expanding these efforts to verify the performance of a larger universe of innovative technical solutions to problems that threaten human health or the environment. ETV was created to substantially accelerate the entrance of new environmental technologies into the domestic and international marketplace. It supplies technology buyers and developers, consulting

engineers, states and U.S. EPA regions with high quality data on the performance of new technologies. This encourages more rapid protection of the environment with better and less expensive approaches. ETV expands past verification efforts, such as the SITE program for remediation technologies and the Pathogen Equivalency Committee for sludge systems, into five new pilots areas. In these pilots, EPA will utilize the expertise of partner "verification organizations" to design efficient processes for conducting performance tests of innovative technologies. EPA will select its partners from both the public and private sectors, including federal laboratories, states, universities and private sector facilities. Verification organizations will oversee and report verification activities based on testing and quality assurance protocols developed with input from all major stakeholder/customer groups associated with the technology area.

The ETV pilots will begin on different schedules, but all are expected to be operational by the fall of 1996. Each pilot will announce its intention to begin accepting technologies for verification in the Commerce Business Daily and in the trade press. By the year 2000, the EPA envisions a program that will be comprised of numerous public and private testing entities covering all major classes of environmental technology.

The Center for Environmental Industry and Technology (CEIT); EPA-New England Region

The goal of the Clinton-Gore Environmental Technology Initiative (ETI) to promote the development, commercialization and use of innovative technology is one of the top priorities for John P. DeVillars, Regional Administrator for EPA-New England (Region 1), through a newly established program called the Center for Environmental Industry and Technology (known as CEIT). EPA recognizes that New England has a rich supply of expertise supporting research and development efforts with innovative ideas and technologies. These could benefit both the environment and the economy, if they can find their way to the marketplace. "EPA has a central role to play in rebuilding New England's economy," DeVillars stated in a press release (Feb. 22, 1995). "This initiative is the cornerstone of that effort. If we are successful in this endeavor, not only will we be able to protect the environment at less cost, but we will also create jobs and economic opportunities in the process." EPA estimates that the environmental industry in New England is a $10 billion industry and employs 150,000 people.

CEIT was opened in Boston, Massachusetts in February, 1995, under DeVillars' direction, to serve the needs of the environmental industry in advancing ETI's goals of research,

development and commercialization of cutting-edge technologies.
CEIT is developing programs and a series of seminars based on the input of focus groups representing the state and federal government, academia, and environmental industry.

DeVillars summarizes CEIT's objectives as:

1. Improving the ability of the industry to gain access to state and federal programs;

2. Increasing access to technology demonstration sites and testing evaluations;

3. Increasing access to capital;

4. Bringing down regulatory and institutional barriers facing the environmental industry; and

5. Marketing environmental products and innovative technologies, both here and abroad.

Accomplishments to date include a series of *"Golden Opportunities" Seminars for Environmental Technology Innovation."* This is a series of six seminars being held at various locations around New England, covering opportunities for federal technology transfer assistance, international marketing and export assistance and financial assistance. Each of the seminars held so far has had excellent attendance, with representation from all categories of private and public environmental industry.

Each of the CEIT objectives is discussed more fully below.

1. *Accessing state and federal programs*:

   In order to improve access to government programs, the CEIT staff serve as a liaison, or point of contact, between the stakeholders and the various EPA, state and other government programs which can assist them. James Cabot, one of the four CEIT staff members stated, "we wanted to avoid having industries bounced around between program offices to get clarifications on what they would be required to do, permit-wise, or what financial assistance was available. We are the salesmen for EPA-sponsored

funding programs and other federal programs which exist in the U.S. Department of Commerce or the U.S. Small Business Association, for example." Continued support following the seminars is aided by the establishment of an 800 number, which has been made available to industry 24 hours a day. That number is 800-575-CEIT.

The current staff is continually reaching out to develop new contacts which can support the needs of their constituents.

2. *Demonstration sites and testing evaluations*:

Currently, the CEIT's main focus on providing demonstration sites is with the Superfund Innovative Technology Evaluation (SITE) program for hazardous waste technologies. Although the SITE program has proven to be a fairly successful program nationwide, it is not without problems. For instance, results of EPA SITE studies can take up to five years to be released; the entrepreneur can be tied up with extensive data collection and reporting mandates; and due to testing standards which are prescribed by EPA, the SITE results may not be accurately testing the manufacturer's claims. Yet, some of these Superfund site studies include innovative processes or technologies for purification of contaminated water and are peripherally relevant to this study. Generally, however, the availability of demonstration sites for municipal wastewater treatment technologies which involve an NPDES permit is limited at this time.

There is a demonstration site at a Providence, Rhode Island municipal treatment plant. This has been used by the Solar Aquatics studies. Gerald Potamis, Chief of the Wastewater Section of EPA-New England Region, also suggested that abandoned wastewater treatment plants might be purchased by EPA or state governments and set up to provide demonstration sites.

3. *Increasing access to capital*:

The lack of funding not only for R&D efforts but also for commercialization of a product has been a major barrier to innovative technology, particularly for small businesses. Through the Golden Opportunities seminars, CEIT has compiled federal financing opportunities from each of the United States Departments of Energy, Defense, and Commerce, the U.S. Small Business

Association, the National Institute of Science and Technology and, of course, the EPA. Private sector funding opportunities are presented as case studies at the seminars.

4. *Bringing down regulatory barriers*:

The state of Massachusetts' Division of Water traditionally held a conservative viewpoint in permitting innovative technologies for wastewater treatment due, in part, to the failures experienced during the Construction Grant program. Many innovative and alternative technologies worked, but were not cost-effective. Carol Kilbride, a CEIT staff member specializing in water treatment programs, notes that a major focus of the New England area is the problem of nutrient loading into coastal waters. "In the past, onsite septic systems were viewed by the Massachusetts Department of Environmental Protection (DEP) as a temporary solution. They believed that once the local population grew large enough, a municipality would form a treatment plant," explained Kilbride. "Permit writers were traditionally conservative and had little experience with non-conventional treatment systems. The DEP is now beginning to promote a new mind set: that onsite systems are here to stay, and that they must support a combination of sophisticated alternative technologies with decentralized treatment." The permitting process is currently undergoing some major revamping in Massachusetts.

To assist in identifying and addressing regulatory barriers of greatest concern to the permitting and utilization of innovative and alternative technologies, Massachusetts DEP has recently formed a task force consisting of representatives from industry, academia and other federal and state agencies to support this initiative. This group is known as STEP, for Strategic Envirotechnology Partnership. Moreover, the ETI has assisted CEIT and the MA DEP by funding the Massachusetts Innovative Technology Coordinator position. This Coordinator, who was hired in May 1995, has the technical expertise required for reviewing innovative permits, and will serve to facilitate actions between permit writers, innovators, the public and municipalities. The position was funded under ETI's 1995 program at $450K. Existing successful permitting strategies will be identified and improved. These strategies will be communicated back to EPA for further development of permitting strategies

throughout the New England Region.

5. *Marketing, both here and abroad*:

Another major obstacle in promoting innovative technologies has been the lack of funding not only for R&D efforts, but also in the commercialization of a product. Through the Golden Opportunities seminars, CEIT has compiled federal financing opportunities which support commercialization from the departments listed in number 3 (above), and from the U.S. Department of Commerce's Advanced Technology Program and the National Institute of Science and Technology. At the state level, the Massachusetts Industrial Finance Agency (MIFA) and the Rhode Island Department of Economic Development are key contacts for financing programs, some of which parallel programs at the federal level. This listing of funding opportunities was diligently compiled over several months by the CEIT staff for the Golden Opportunities Seminars on Federal Financing Opportunities. Through these seminar presentations, attendees can identify possible funding sources appropriate for their needs.

In order to promote the sale of U.S. environmental products and services worldwide, EPA New England is working with Massport, the Rhode Island Export Assistance Center and other regional trade organizations and industry associates to develop informational packets, which are distributed at the CEIT seminars. According to DeVillars' press release, "The global market for such services is estimated at $300 billion. By comparison, the aerospace products industry had a global market of $180 billion in 1990. The United States is considered the world leader in environmental technology, accounting for $134 billion and employing 2 million people."

Paul Hardiman, Division Executive for the Environmental Services Division at the Bank of Boston, supports CEIT enthusiastically. "Many of the Bank of Boston's customers will want to tap into the expertise and practical help that CEIT has to offer -- and we'll encourage them to do so. CEIT builds on the positive steps already taken by EPA New England, to put into place a private/public partnership, and that's welcome news for smaller businesses." The program has been well received by private and public companies and by those who must regulate them.

With all its apparent success, there is still much work to do. Not all of the six Golden

Opportunities Seminars have been fully developed as of this writing. Cabot would like to investigate the potential for a showcase newsletter which would be made available through an online network, possibly through the Internet. This would provide an avenue to reach a large audience rapidly, when timeliness is an important factor for funding opportunities, for example. In conclusion, Cabot feels that although EPA Headquarters labels CEIT as being very proactive, he often feels his group's hands are tied by lack of staffing and by budget limitations. "We are fortunate in that DeVillars has made this a priority, and has essentially 'found' money in other areas to print our brochures and do mailings," Cabot said. "The ETI money was supposed to fund a half position at each of the Regional EPA offices; we got a full-time person, so we have a staff of four. But, we really don't have enough staff, and we are really here on 'borrowed' time. We also need some kind of discretionary funding in order to be spontaneous to our clients' needs. High visibility is important, but it creates complications which need immediate attention in order for us to remain effective." The accomplishments of the CEIT are clearly noteworthy, yet their value may not be fully realized due to these shortages.

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The Water Environment Research Foundation

The Water Environment Research Foundation (WERF) was established under the auspices of the Water Environment Federation (WEF) in 1988 to "share the vision and solutions for the future" through the advancement of science and technology which benefit the water quality profession and its customers. Both organizations are not-for-profit. The Water Environment Federation (formerly called the Water Pollution Control Board) was founded in 1928; its mission is to "preserve and enhance the global water environment through technical support and education." WERF is the research arm of WEF. WERF's funding is through voluntary memberships which form public-private partnerships between wastewater utilities, consulting firms, and large corporations (such as Shell Oil, Kodak and Chevron). EPA also contributes funding, including Congressional add-ons, providing about 17% of the WERF research commitments for FY 1990-1996.

WERF manages research under four major areas: collection and treatment systems, integrated resources management, residuals management and human health and environmental affects. An assessment of what research is needed is performed through an annual survey of its members. The results are efficiently tabulated and research is prioritized. WERF seeks cost-effective, publicly acceptable, environmentally sound solutions to water pollution control problems. Applied and basic research is performed by contracts with individual organizations, primarily through wastewater treatment utilities, universities and industrial and commercial firms. Research overseen by a 14-member Board of Directors, a Utility Council, an Advisory Council of Industry Leaders, and a Research Council. An independent advisory committee of scientists and engineers helps to select researchers and provides periodic review and advice to ensure objectivity. A stringent peer review process is also followed with each project.

Through their participation and membership contributions, members can take advantage of leveraged resources with federal funds, co-funding by manufacturers and in-kind services, making wise use of research dollars. According to a recent WERF newsletter, subscriber support of WERF will exceed $2 million for the first time in 1995, with wastewater utilities providing 86% of the Foundation's subscriber funding. (*Progress* newsletter, 1994). An example of an outcome:

> Additional savings were made possible as a result of [another WERF project which studied] regulatory modifications made by the EPA as a result of hydrocarbon emissions work. Originally imposed standards for hydrocarbon emissions would have imposed capital costs on utilities estimated at nearly $1 billion. New data produced

> under the WERF study offered conclusive evidence that standards protective of public health could be imposed without requiring extraordinary expenses for utilities. In addition, through this research, it was discovered that biosolids could be incinerated at lower temperatures, resulting in additional cost reductions in operations." (p. 3, *Progress* newsletter, 1995).

Clearly, these kind of cost savings are of interest to all stakeholders and to taxpayers. During 1994 alone, WERF published 9 new final research reports with a value, according to the newsletter, of some $1.8 million; at least 7 other major research projects are in progress. The WEF 1995 *Technical Resource Catalog for Environmental Professionals* describes over 60 pages of technical publications, training/certification materials and public outreach literature. These materials are available in the format of technical books, manuals, videos, brochures and even bill stuffers. Some are in foreign languages. These materials can provide technical support for municipalities considering innovative technologies such as UV vs. chlorination, incineration or innovative sludge processing. They also provide to the consultant or manufacturer peer-reviewed, third-party evaluations of certain new technologies. Public concerns can be addressed with the Public and Educational Outreach programs, such as the *Biosolids Recycling Public Awareness Program* and bill stuffers: *Biosolids Recycling: Beneficial Technology for a Better Environment*.

Target Collaborative Research, started in 1990, is a new program of WERF which allows the Foundation to expand its research into some fairly narrow topics. WERF actively seeks sponsorships to fund these projects. It allows subscribers to have some say in what they would like to support beyond the annual survey selections, and to take advantage of the pooling of financial and intellectual resources. Current sponsorships are being solicited for an evaluation of Whole Effluent Toxicity (WET) tests**,** to an evaluation of Combined Sewer Overflow**,** and a marketing manual for Biosolids and Water Treatment Residuals**.** All of these projects address barriers to innovation.

This private-public partnership is one approach to decision-making and managing research. The results are made available for technology transfer in a variety of formats and languages. The cost is shared across the water quality profession and across the public and private sector. Although it has been stated that WERF is able to carry out only about one-fourth of the research that is needed, WERF is unquestionably accomplishing a great deal with current resources, always with the goal of "sharing the vision and solutions for the future."

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The National Sanitation Foundation International: A model for providing national certification for new technologies

The National Sanitation Foundation International is a private, independent, not-for-profit organization recognized worldwide as a third-party certifier of products and systems in health and the environment. NSF (not to be confused with the National Science Foundation) is accredited by the American National Standards Institute (ANSI) for all of its product certification programs. With its professional staff, NSF develops and conforms to ANSI uniform standards with modern, well instrumented research facilities. The product testing and certification program is voluntary. According to NSF's promotional literature, "NSF is a highly regarded, classical third-party provider; objectivity and credibility are critical assets. When conforming products become certified, the use of our formally registered Mark is then authorized by the producers." NSF certification offers a valuable marketing tool which supports the claims of new and innovative products, reducing barriers for the manufacturer.

NSF is best known for its certification programs in food processing and handling, spas and hot tubs, home treatment of drinking water and wastewater and plumbing components. The wastewater program is limited to a standard that covers aerobic systems used by individual homes with a maximum capacity of 1500 gpd. Regardless of this limitation, the program provides an interesting model for the development of an independent and well-respected certification program which could be emulated or expanded to provide a broader spectrum of certifications for wastewater products.

The wastewater technology program is administered by a well-qualified professional staff in Ann Arbor, Michigan. A testing and demonstration facility for alternative onsite treatment technologies is located in nearby Chelsea. The testing facility intercepts raw wastewater prior to its entry into the Chelsea municipal plant. The raw water is closely monitored for treatment and then sent back through Chelsea's municipal plant. Data are collected through a six-month trial period by NSF staff. Those that meet all the requirements set in ANSI standard 40 or 41 become certified. Once certified, in order to continue the use of the NSF Mark, the manufacturer is required to perform periodic testing, maintain records and agree to unannounced inspections and audits.

Thomas Bruursema, Director of Testing Programs for NSF, believes his program is well known among regulatory groups and municipalities. He feels that EPA doesn't get involved in the approval process for individual onsite systems because there is so much variation between state regulations and, within a state, local regulations. "Often, the

regulations are under the state's department of health, due to the potential impact on groundwater and drinking water," stated Bruursema. "But they may also be regulated by the state's environmental divisions." The NSF certification program follows the ANSI guidelines which were developed to satisfy the EPA secondary treatment guidelines for wastewater. These guidelines are not required for onsite discharges, but are certified to perform equivalently.

The NSF certification program is totally voluntary. Those producers or innovators who would like to participate fill out an application, which is reviewed by a board and approved. The product or system is tested for six months. Ten testing sites are available, so there is rarely a waiting period. A full time staff manages the data collection and ensures the NSF standards are strictly met. The cost to the manufacturer is steep, particularly for the small business owner: costs start at $60,000 - $80,000 for the test and investigation. An annual fee of $5000 is required for NSF listing and for the auditing fee.

Currently, twelve aerobic treatment wastewater systems have obtained certification through the NSF program. According to Bruursema, there are ~~some~~ other institutions which provide second party certification, but these do not have the same level of recognition as NSF does. Other certification test centers exist at Louisiana State, Baylor University in Waco, Texas, Texas A & M and Michigan State.

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The New York State Energy Research and Development Authority: A public benefit corporation

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created by the New York State Legislature in 1975 as the state organization primarily responsible for planning and conducting energy-related research, development and demonstration programs (RD & D). NYSERDA manages an impressive energy research program to help secure New York State's future energy supplies while protecting the environment and promoting economic growth. Municipal wastewater treatment and sludge processes, which are energy intensive processes, are one area of RD & D. NYSERDA's mission, as stated in a NYSERDA publication is:

> "...to develop *innovative solutions* to some of the State's most difficult energy and environmental problems. The Energy Authority places a premium on collaborative activity, including an extensive outreach effort intended to solicit multiple perspectives and to share information. The Energy Authority and its staff have a commitment to public service, striving to produce quality results promptly and to manage public funds responsibly." (*Research Projects Update, 1994* , p. iii)

The RD&D program is funded by an assessment of the intra-state gas and electricity sales of the state's investor-owned utilities. Additional funding is provided by the New York Power Authority and NYSERDA corporate funds. Equally important are co-funding projects from a variety of partnerships. These partners include the Electric Power Research Institute (EPRI), the Gas Research Institute, the National Renewable Energy Laboratory, utilities, universities (mainly located in New York), industrial firms, private engineering and scientific firms, local governments and State and Federal agencies. The leverage provided through co-funding enables every one research dollar to stretch into three dollars.

The NYSERDA Research Projects Update compiles summaries of nearly 300 different projects being funded as of September, 1994. Environmental research specific to municipal wastewater and sludge consisted of 21 new projects and an additional five completed projects out of approximately 300 research summaries listed. Many other research and demonstration projects dealing with pollution prevention and waste reduction also fall under New York's SPDES program. Some of these projects include: constructed wetlands in Minoa and Monroe County, anaerobic treatment of landfill leachate, testing of a "floating biological contractor" designed by KLV Technologies to raise the treatment efficiency of older activated sludge systems, a sludge dewatering and combustion project

using a paper pulp blend to improve combustion, and evaluations of various monitoring tools. Co-funding for these projects has been provided through the U.S. DOE, the Gas Research Institute, the National Renewable Energy Laboratory, the New York Gas Group, NYS DEC, Monroe County, Erie County, Clarkson University, URS Consultants, Auto. Firing Inc., KL Technologies, and Clough-Harbour & Associates. In-kind services were contributed by many others, resulting in an overall extremely efficient use of research funds.

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National Small Flows Clearinghouse: Informational support for small communities

The National Small Flows Clearinghouse (NSFC) was established in 1977 as an informational clearinghouse for both products and services needed in small communities to more properly manage their wastewater treatment facilities. While all community budgets have become more strained, the risk of failure faced by small communities is accentuated by the smaller tax base supporting the treatment system and frequently, by the lack of in-house expertise. With environmental regulations becoming more complicated and more stringent, the NSFC is available to provide guidance in the form of documentation and services to assist those with 'small flows.'

NSFC is accessible through an 800 number and through electronic bulletin boards. Staff experts are available to provide telephone consultation and referral services for wastewater issues. NSFC maintains several databases covering innovative and alternative treatment systems and case studies, references from the Small Flows library and a list of referrals for various outreach agencies and contacts. Many of its publications are free or have a minimal charge. The products include quarterly newsletters, case studies in video or print, regulations, design manuals, operation and maintenance manuals and innovative/alternative technology studies applicable to small flows. The computerized bulletin board service is also free and offers specialized electronic conferences and open forums for discussion of wastewater issues.

The NSFC is affiliated with the National Drinking Water Clearinghouse and the National Environmental Training Center for Small Communities. Together these programs comprise West Virginia University's Environmental Services and Training Division.

Reference:

National Small Flows Clearinghouse. 1993 Guide to products and services. West Virginia University: Morgantown, VA. 1993.

U.S. EPA Office of Research and Development's Research Centers

EPA Office of Research and Development (ORD) is the umbrella which houses a group of research programs located all across the country. These include the Environmental Monitoring Systems Laboratory, the Environmental Research Center, and the Risk Reduction Engineering Laboratory (RREL), which are located in Cincinnati, Ohio, the Great Lakes Research Station in Grosse Ile, MI, the Monticello Ecological Research Station in Monticello, MN, the Robert S. Kerr Environmental Research Lab in Ada, OK, and Environmental Research Labs in Corvallis, OR, Duluth, MN, and Narragansett, RI. These research facilities have, in the past, been geared to provide opportunities for research and/or technology transfer. The ORD makes research publications available to the public and operates an electronic document ordering system through CERI, the Center for Environmental Research Information in Cincinnati, OH.

While in the past, these research facilities may have been effective in performing applied research which was relevant to wastewater treatment, the environmental community today seems to have only a vague understanding of their functions. Many wastewater industry experts involved in R & D efforts no longer consider these sources for current research. The current priority seems to be with hazardous waste issues under the SITE program. Several of those interviewed find ORD's methodology of soliciting proposals and determining where to spend its budget to be excruciatingly slow. The perception is that it is very difficult to make the wheels of the bureaucracy move so that concrete research, with practical applications, can get accomplished.

ORD's successful Small Business Innovation Research program, described in the next section, is a noteworthy exception.

U.S. EPA's Small Business Innovation Research Program (SBIR): Funding for promising, high risk research

The Small Business Innovation Research Program (SBIR) is a small two-person office under EPA's Office of Exploratory Research within the EPA Office of Research and Development. ETI awarded $771,000 to SBIR in 1994 and $2,386,000 in 1995. The program provides funding through a competitive application process for small businesses to undertake cutting edge, high-risk or long-term research that has a high potential payoff if the research is successful. The business must have under 500 employees. The research must be *applied* research which is solicited in areas of interest to the EPA and which relate directly to pollution prevention control. All forms of media are eligible, including municipal and industrial wastewater treatment and drinking water treatment. Desirable outcomes include technological innovations producing new commercial products processes or services which benefit the public and the environment, and can be used to pave the way for other technological advancements.

The program has three phases. Phase I awards are used to provide evidence that a new technology will be successful. Successful Phase I recipients are then eligible to be considered for Phase II funding. Phase II is the principal research effort for those projects that appear most promising for commercialization. Phase III is for product or process development using non-SBIR funds, such as from venture capital or large industrial firms who wish to pursue commercial applications of the government-funded research. Each successive award receives more money, but there are fewer awards.

The SBIR program is managed by Donald Carey. Each year, he reviews about 500 proposals and makes recommendations to a board of experts representing private industry and government. The board makes the final selections. The awards are extremely competitive. After ten years of managing this program and others in private industry, Carey is confident that it is in small business that we find the 'innovation brains.' "The research done at universities may be interesting, but often has no commercial value," stated Carey. "They have that ivory tower mentality. On the other hand, there is so much idea sharing. Businesses put together creative ideas which may combine concepts from research which is published through academia and create a truly innovative and commercially viable technology. I feel this is a direct byproduct of the availability of electronic resources." Kevin Gleason, Ph.D., recipient of Phase II research funds for his company's work with selenium extraction from wastewater, is pleased with the SBIR program, adding, "This kind of support is definitely needed to overcome the large amount of inertia in getting something truly new and innovative on the marketplace."

It is hoped that SBIR's federal support for small businesses which require a high front-end risk investment will provide sufficient incentive for some to pursue their research. Yet, the majority of funding for 1993 was given to research areas outside of the wastewater field (air emissions and solid and hazardous waste disposal were main recipients) and it appears that only a small percentage of water quality research professionals are aware of this program. There is no telephone listing in the 1994 EPA Headquarters Telephone Directory under the name of the program (Small Business Innovation Research Program) or under the Office of Exploratory Research. Solicitations are available by written request only. Carey's two-person office must handle a very large work load. While the recipients of the awards seem very pleased, this valuable program is understaffed and is hard-pressed to respond to questions and provide the technical assistance or technical transfer which are part of the program's mission statement.

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Personal Communication:

Carey, Donald, Manager. Small Business Innovation Research Program, EPA. Wash., DC. (202) 260-7899.

Gleason, Kevin, Ph.D.. TDA Research, Inc. Wheat Ridge, CO. (303) 422-7819.

The Green Chemistry Project for pollution prevention

The Green Chemistry Project was formed to promote the reduction and elimination of hazardous substances in the manufacturing and use of chemical products. Pollution prevention is promoted by collaborating with organizations such at the U.S. Department of Energy, The National Science Foundation, The Los Alamos National Laboratories, The American Chemical Society, The Emission Reduction Research Center and the Center for Process Analytical Chemistry.

Other pollution prevention initiatives are ongoing under ETI with printed wiring board, metal finishing, paint stripping, and pulp and paper industries. While these initiatives go beyond the scope of this report, they are noted here for further research.

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Gardiner, David M. *Environmental technology highlights: on-going and planned initiatives.* U.S. Environmental Protection Agency: Washington, DC. December 1994.

Summary Report: Focus Group Meetings for Innovative Technology 7. Project on Barriers, Barrier Solutions and Incentives

INTRODUCTION

The use of conventional technology to deal with community wastewater pollution control and prevention is, for the most part, a given. Most communities, consulting engineers and regulators give little or no consideration to the application of innovative technologies when their present systems fail or when they are faced with the construction of systems for new industrial or municipal service. The purpose of this project was to determine, "Why?" Why is conventional technology the seemingly only answer when some innovative approaches can clearly be as efficient and more cost-effective than conventional methods? What are the common barriers being raised to more widespread use of innovative technology, why do they exist, and what can be done to counter those barriers?

With completion of the research component of this project, The Rensselaerville Institute convened four focus groups. The first two were held in Washington, DC and Chicago, IL, and the second two in Atlanta, GA and Rensselaerville, NY. The intent of convening these focus groups was to:

- verify research findings,

- expand on those findings with field experiences of the focus group experts,

- gain suggestions for potential strategic solutions to existing barriers that dissuade communities from using innovative wastewater technologies, and

- have participants elaborate on tactical approaches which could be tested to overcome barriers to, or provide incentives for, the use of innovative technologies in dealing with wastewater problems.

Thirty five experts, representing regional and state regulatory agencies, regulated communities, consultant engineering firms, and academia, participated in the four focus groups. The areas of discussion from those meetings are summarized below. These areas are:

1. Expert Discussion of the Identified Barriers to the Use of Innovative Technology;

2. Identification and Discussion of Additional Barriers to the Use of Innovative Technology;

3. Strategies for Addressing Barriers to the Use of Innovative Technology; and

4. Some Suggested Tactics for the Encouraging the Use of Innovative Technology to Address Wastewater Pollution Problems.

Expert Discussion on the Identified Barriers to the use of Innovative Technology

As a starting point, focus group members reviewed the Introduction and Summary of the Barriers derived from the Institute's research (pp. 1-14 of this report). There was agreement by all members that these were in fact major barriers to the use of innovative technology**:** aversion to risk; lack of early trials and credible data; lack of sufficient technology transfer; federal regulations; state and local regulations; and lack of funds. Highlights of the discussion of each of these six barriers is presented below.

1. Aversion to Risk.

Each stakeholder demonstrates a resistance to the use of innovative technology because of the level of risk the new technology carries (or perceives to carry; for some, the mere perception of failure will make the stakeholder risk-averse to innovative technology). Participants clearly stated that in order for them to be willing to be more open to trying innovative solutions, there had to be a more even sharing of the risk load by all parties involved. Some points of discussion were:

- The risk of miscommunication among stakeholders when discussing technology and technology requirements. There is often a disconnect between the consultant engineer (the technologist) and the regulator because they come from different perspectives - the engineer is concerned with the technology while the regulator is concerned with the end-of-pipe numbers. Thus, the first tends to overstate the process while the second overstates compliance. Also, permit writers often don't understand technical aspects, whereas engineers often aren't able to translate technical criteria into effluent limits.

Risk of system failure leading to fines and penalties before the "bugs" can be worked out of the system. An industrial representative stated that risk aversion is a major driver in the

choice of technology. Industry complies to avoid enforcement actions. In the case of industry, risk could both be reduced if longer compliance schedules were possible and managed if a parallel fallback system was available in the case of failure of the innovative system. But most industries feel they have dealt with the problem - they've invested in conventional systems and are not willing to invest in innovative technology even if the latter is more effective as long as the industry is in compliance.

- Risk of litigation and loss of reputation. Consultant engineers will be conservative as long as they are required to share the risk because they want to protect reputation and prevent litigation. Also, engineering schools tend to train engineers to be conservative and rely on conventional approaches to solving problems. Once in practice, engineers tend to recommend use of proven technology, even if some innovative technologies might do the job at lower cost or with greater effectiveness, in order to control their level of risk in any given project.

- Risk of investment loss on the technology development side. Inventors of innovative technology (e.g. biological phosphorus removal) risk loss of monetary return because patents for intellectual processes are often not respected as patented and therefore, the technology is used without reimbursement to the inventor.

- Risk of investment loss on the implementation side. Communities, particularly small communities, tend to select local consultants and known (conventional) technology. The fear is that if innovative technology fails, the community will have to purchase a second system. Most small communities do not have the funds or tax base to afford system replacement.

2. Lack of Early Trials and Credible Data.

Another common reason that innovative technology is not used is that it is "unproven", and is competing in a world of highly conservative stakeholders. Being first to use a piece of technology is not an honored position! Introducing technology into the arena of wastewater pollution control and prevention is a "Catch 22" situation: it is not trusted until it has been shown to be effective but few are willing to put it to the test and gather the data (and risk being out of compliance) so that the technology can build the trust of consulting engineers, regulators and communities.

Some of the specific comments made by the experts at the focus groups in regard to this

issue were:

- This barrier speaks to the maturation stage of the technology being tested. It's inappropriate to take an innovative technology and put big bucks into it at the earliest stages. One can't go directly from bench chemistry to the pilot test. A time for maturation is needed, and must be provided in a "penalty-free" space.

- The term NIH (not invented here) is used, especially among engineers. They don't believe data from elsewhere -they want to experience the technology themselves before they are willing to trust it (risk aversion).

- States don't tend to share data on a given technology, even if data are available. Thus, each time technology is suggested for application, the developer has to reproduce it, there is no assumption of comparability of technology's use in one location to the next. Engineers in particular have a harder time evaluating technologies on a conceptual basis; they want to see the technology in use in order to believe it works.

- There is little data on real costs of buying and operating a system. The public has very little knowledge about what things cost; cost data are not public property. It's not just the cost of construction, but also the costs of operation that have to be considered.

- Cost data become a "trade secret" with engineers. These data are part of the bidding process, so it's hard to standardize them.

- Data received by EPA, which the Agency uses to establish effluent guidelines, are often biased and inflated by the data providers.

3. Insufficient Technology Transfer.

Experts agreed that insufficient technology transfer was a large barrier to the spread of innovative technology. There does not seem to be a consistent conduit for transfer, and no consistent effort made by key stakeholders to develop such conduits. Some of the points made regarding this barrier to innovative technology were:

- Generally, there is no institutional framework to share data. However, there are a few exceptions such as: Western Governors Association (four western states);

Regional Technology Consortium (PA, DE, MD) a Memorandum of Understanding among the states of CA, IL, MI and MA regarding the testing of technology and sharing of information - each state has a verification center. In addition, there is STEP (Strategic Envirotechnology Partnership) in Massachusetts which helps technology developers with business planning, technology development, technology evaluation, finding demonstration sites, etc. These groups are a way to obtain credibility for the technology because the developer has help in collecting reliable data. But this process of group formation for sharing purposes is infrequent in the arena of wastewater technology.

- The underlying perception that everybody's waste is different and technology transfer therefore, suffers because of this perceived uniqueness**.**

4. Federal Regulatory Barriers.

Potential users of unproven technologies fear the consequences of being out of compliance with the regulations. No one is motivated to find a more effective or cost-efficient way to deal with wastewater when conventional methodologies are capable of meeting compliance schedules and effluent limits. The present federal regulatory requirements cause stakeholders to focus first and foremost on compliance with stated limits and only then do they consider water quality improvement. Some expert comments in regard to this barrier were:

- Those who could do a better job than just meeting compliance don't, because it becomes the expectation. Creates a mindset of "ratcheting down". The "anti-backsliding" laws are a powerful barrier.

- The current political system favors the use of conventional systems, and users strive only to comply. We need to create a culture that fosters continuous improvement as new problems (e.g. phosphorus) and new solutions come along.

5. Regulatory Barriers.

Short-term solutions, particularly in smaller communities, are often the choice when the system breaks down. Most small communities tend only to act when faced with a crisis of

penalties and fines for non-compliance because they do not have the financial and time latitudes to test innovative solutions to the problem. Small communities also do not have the financial backing to be able to challenge consultant recommendations or regulatory requirements.

Some comments made by focus group participants included:

> - States have different regulatory requirements for wastewater, with some states being far more stringent than others. There is no consistency among state requirements on a nationwide basis. While the intent is to allow states flexibility, the end result feeds into the risk aversion of consultants called upon to design solutions for communities sharing a watershed or waterbody. Their solutions are highly conservative and seek to achieve the most stringent requirements for the states affected. This inconsistency of regulatory requirements among states is a strong barrier to both the development and spread of innovative technology.
>
> - State permit writers tend to be entry level jobs, filled by people lacking experience both in technical understanding and negotiation skills with engineers and the community. Therefore**,** these individuals tend to adhere strictly to regulatory requirements which may or may not be appropriate for any given community's system, e.g. require that the system deal with a pollutant that isn't even present in the wastewater discharge.

6. Lack of Funding.

As one focus group member stated, "If there were enough funding, the barriers to innovative technology would be redefined; you'd either leap over them or break through them."

Lack of funding is an omnipresent problem across most stakeholder groups vis a vis selection of technology to apply in a given situation. Academia reports lack of funding to develop and test innovative technology, particularly at the pilot-level of testing. Small communities are highly sensitive to lack of funding: in some cases, they prefer to do nothing rather than spend the money on a wastewater treatment system, conventional or otherwise.

Regulatory agencies cite lack of funding as the reason for hiring inexperienced permit writers. Few communities (Atlanta is a notable exception) commit the funds to have

engineering expertise at the regulatory level that would facilitate review and consideration of innovative technologies for a given permittee.

Some experts noted that the problem was not lack of funding but rather inappropriate use of available funding whereby unwise decisions were made to spend money on technology that was ineffective (but the data showing poor performance were not shared until too late).

Some also noted that the desire to try innovative technologies was present when the money was received in grant form (e.g. Construction Grant Program), but the desire waned quickly when grants were replaced by low-interest loans and pay-back was required (State Revolving Funds). Also, when the Innovative/Alternative technology program was in existence, numerous states lost their "I/A" funding for various reasons

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Some also noted that the desire to try innovative technologies was present when the money was received in grant form (e.g. Construction Grant Program), but the desire waned quickly when grants were replaced by low-interest loans and pay-back was required (State Revolving Funds). When the Innovative/Alternative technology program was in existence, numerous states lost their "I/A" funding for various reasons on non-use, one being the lack of definitional understanding of what innovative technology was.

Funding will continue to be a barrier to the development and application innovative technology as long as the existing command-and-control mindset is in play. Stakeholders will take the safe route of conventional approaches whether appropriate or not, which will dissuade people from wanting to spend money on possible failure. The risks involved are too great to persuade people to invest in the "unknown".

Identification and Discussion of Additional Barriers to the use of Innovative Technology

Some additional barriers were added to the initial list by members from each of the groups. These included:

- The lack of a "level playing field" among stakeholders on the meaning ~~on~~ of innovative technology (what is innovative to some is conventional to others), with the differences in opinion and understanding so great that they cannot be solved simply through technology transfer. This proves to be a great barrier when trying to develop a market for a given technology.

- The fact that present conventional technology works, and does allow communities to be in compliance. There is little incentive for trying something "unknown" for existing industries and larger municipalities. Conventional technologies work for 90-95% of the pollutant problems.

- The market for wastewater technologies was strongest in the 1970's-80's. Participants, particularly consultant engineers, felt that market has been filled. The remaining markets are small communities and start-up industries in the U.S., and the export market. These available markets are not well understood by many of the stakeholder groups, and are growing too slowly to attract much attention. As one consulting engineer stated, "We don't seek out small communities, we wait until they come to us."

- The incentives for exploring innovative technologies for wastewater are not clearly evident. The two reasons cited for using innovative technology are: 1. to do a better job, or 2. to do the same job with fewer resources. Most participants ruled out the first because experience has shown that improvement becomes expectation in the regulatory arena. The second is often ruled out because of the penalties for failure of such technology, and because no reward system is in place as an incentive for trying something new. There could be a number of potential "draws" for innovative technology, such as ease of operation, utility, durability and operability.

- As a result of the growing competitiveness in academia, our data are now collected in the method of the Least Publishable Unit: the need to have a unique finding for a thesis drives students to do research on the smallest scope possible in order to get a publishable paper. This hinders the development of break-through technology.

Strategies for Addressing Barriers to the use of Innovative Technology

Experts noted that, from the point of reason, there two strong incentives for pursuing innovative technology: 1) to find something that will do the same job for lower cost, and 2) something that will help a stakeholder avoid litigation. There is no real incentive, under the present system, to find innovative technology that will do the job better than conventional technology.

Participants noted a couple of situations that could prove to be an incentive for innovation at this stage of wastewater treatment. Two key points made by experts:

1. The present infrastructure is at the end of its 20-year lifespan. The treatment systems now in place in most wastewater treatment plants were developed during the 1970's, with the anticipation that it would have a 20-year lifespan. As we close out the 1990's, these systems will be coming to the end. This creates an opportunity for consideration of new or more efficient systems for a large number of facilities. The challenge is to determine, before these systems break down, what we want to accomplish in the area of wastewater, and what are the political, social and economic ramifications that would result with the achievement of those goals.

2. In order to support innovations in waste water treatment, there needs to be a shift in the mindset about wastewater pollution control and prevention, and in the most appropriate roles of the stakeholders involved.

Participants in the stakeholder focus groups felt that the present system of wastewater pollution control and prevention has no vision, goals, or focus to implement new technologies, since conventional systems using traditional treatment methods tend to "do the job" satisfactorily. If there were a paradigm shift to a risk-based approach that provides communities the latitude to prioritize problems and be flexible in the manners in which they deal with those problems, innovative technology would be more in demand, because the consideration would then be "what are we trying to accomplish, and what are the technological possibilities that could get us there?"

The roles of regulators would need to change to that of partnership rather than enforcer. There would need to be a greater openness to innovation, particularly through greater flexibility in compliance schedules and allowing for "soft landing"when compliance is narrowly missed. Regulators would need to shift their mindset more toward real "sustainable development" in support of non-conventional treatment systems.

Another point raised by participants regarding understanding the value of innovation and developing strategies to overcome present barriers was this: innovation needs to be considered from the procedural as well as the structural perspective; not all innovation involves a new "black box", but might just be a new way of "doing". For example, pollution prevention methods introduced into a plant's production process have proven to lower both cost and risk, by reducing or even eliminating chemical waste products from the plants effluent.

Focus group members were asked to think of strategies that might be useful for overcoming the barriers listed above. These discussions did not get into the depth of "how to" (tactical approaches), but rather got the experts thinking about fresh ways of looking at conventional wastewater treatment and the way it is carried out presently, and determine points in the process where a new view or approach - on the part of the regulator, consultant engineer, or community - might hurdle some of the barriers that have grown from the conventional approaches. Some of the points they noted are listed below.

Specific strategies suggested by focus group experts to address the identified barriers:

a. Reducing, managing and off-setting risk:

Participants made numerous suggestions of areas that could be explored which would reduce, manage, and offset risk. These suggestions included:

- Recognition and rewards to consultant engineers for "clever" applications would offset some of the risk.

- risk would be reduced with a waiver system that would protect engineers from normal liability when applying innovative systems, including protection from citizen suits.

- Development of "Innovation Zones" (similar to Enterprise Zones) to test innovative technologies, i.e., individual facilities that would be protected from litigation when testing an innovative technology for a class of facilities.

- Efforts made to improve communications of the "triangle": regulator, regulated community (and financier), and consulting engineer. Establish non-binding

opportunities for them to talk, so that permittee and permitter can float ideas past each other in a non-threatening and collaborative way.

- Provide permittees incentives to solve problems before they **become** problems, e.g. the sugar industry discharges large quantities of ammonia each day. The industry came to the regulators before the regulators went to them to discuss possible solutions to the problem. This allowed the regulator to be a partner rather than an enforcer, and thus share the risk.

- Allow for "soft landings" for those facilities that try innovative technology and find that it doesn't work perfectly the first time. Allow more flexibility in time and requirements for compliance.

- Encourage consulting engineers to sit on advisory panels (working with regulators and permittees) for the use of innovative technologies. This reduces the engineers' future risk with new technology, because they get to see its application without assuming any liability if it fails, and on the other hand can turn successful trials into marketing opportunities for their businesses.

- Use non-compliance situations to test out innovative technologies, such as state facilities which do not have the liability risk, or facilities that are not yet regulated but will be in the future. These settings provide more risk-free situations where innovative technology can be tested and refined.

- Offer partial penalty rebates to facilities that have been fined for non-compliance, and then are willing to try innovative technologies to deal with the problem.

- Focus funding opportunities on incremental innovations on existing systems rather than revolutionary innovation that changes an entire system. This lowers the risk to the testing facility because of the relative ease to quickly note success or failure of the innovation, and revert back to the conventional approach in the case of failure.

- Make known the vision of what it is we are trying to achieve for wastewater. Despite all the work and money invested in this area, people aren't focused on doing things differently than the conventional wastewater systems used since the 1950's. Once a vision is known, this would act as an incentive to the regulated community, because they would understand where they need to be going, and could then make more rational decisions on what they need to do to reach those

goals.

- Develop a common vision of what the environment ideally ought to look like and take into consideration the economic constraints, common goals and understanding of how to reach them. Currently, this program is a state-run program in most states, however, and the chain of logic has been pretty well thought out by the states. While 40 states have permit authorized discharge programs ; 10 utilize regional EPA permit writers. All need a common vision, to also be able to explain the differences in requirements between states for the same industry. For watersheds that are shared between states, then, there is a prime opportunity for negotiation and an "open door" for innovative technology consideration.

b. Overcoming the barriers of lack of early trials and credible data:

- Work on building trust between stakeholders. Foster the "partnership" idea between regulators and the regulated community, where enforcement is the very last resort, and mutual respect and assistance are the first steps in solving wastewater problems. This would facilitate partnerships working together on trials, and on sharing data.

- The original baseline data for existent technologies is based on research done in the 1960's and 1970's, much of which is outdated and inappropriate for dealing with today's pollutants. U.S. EPA is mandated by Congress to review these technology-based effluent units for each industry, however, the updated guidelines are exceedingly slow to finalize as they get bogged down in litigation for months and even years. Yet when no update has been implemented, regulations must rely on these outdated regulations. EPA needs staff to update their data to be more credible. Academia and POTWs are two important sources of research information, although the caveat is that academia is more and more funded by corporate funds to get specific results.
- A balance is needed of deep thinkers and practical appliers; one way to address the barrier might be to team up consulting engineers with academics to get a combined theoretical/practical study, e.g. at Minoa, was Clough-Harbor Associates teamed with Clarkson University. AMSA and WEF are also two strong sources of credible data.
- Develop a list of those who'd be willing to try innovative technology or processes to establish platforms for testing new technology. For example, the Los Angeles County Sanitation Districts and the research division at Chicago which does

technology transfer with Japan on pretreatment, stormwater, disaster recovery. Most municipalities have some R&D capacity, but varies depending on size, capabilities, Ph.Ds, etc. Knowing which municipalities have this capacity and would be willing to use it would offer new locations for trials and data collection.

- In MN, there is a yearly "innovative operators" conference, where wastewater system operators from communities of all sizes get together and share things they've tried. The only problem is capturing the information shared by these innovators, because many of the things they try out work, but they don't have the capacity to write their innovations up and distribute them.

- Allocate funding specifically to do the pilot size studies ($15-20K), which are just below industrial scale, where the data are closest to reality and where failure is most likely to show. We can get some data from "platform" models, but it is very costly to do testing of innovative technology at real size. Many University students perform bench size research or bathtub size ($200 for materials). However, this is too small to identify real trouble spots and may not be accepted as credible research.

- To really test some innovations, they need to be integrated into the rest of the infrastructure of the system. It is harder to get real data when changes are made just upstream from the plant. There are a lot of small tests going on all the time, but the problem is lack of scientific documentation. People in the wastewater field don't know about the tests. It would be possible to address this barrier by identifying large plants which are comprised of multiple small units of operation. The technology can be tested at just one of the units; the overall impact on effluent won't be large if the innovation doesn't work, and yet the developer would be able to tell if it was effective. However, as stated above, the test must be big enough to be significant and credible for it to have any acknowledgement by the field. Graduate students may be used to perform some of the research to make it more affordable.

- RCRA and Superfund have data that are worth looking at in some areas, e.g. groundwater remediation. But the technology for groundwater is not as advanced, and because there is not a dominant technology, this would act as an incentive for stimulating innovative technological development efforts. Wastewater is a mature field, but because groundwater is a new field, there are more opportunities for profit making and sites for testing technology.

c. Improving technology transfer:

- Dept. of Commerce Rapid Commercialization Initiative, which is in the process of being developed, promises to provide a good path for technology transfer.

- There are two ways to increase the number of demonstration sites: show your client that they will save money; or, make money, or, show your client you will prevent them from going to jail. There needs to be an Innovation (safety) Zone in which to do this...it truly is hardest to get the first client to be the guinea pig for an innovative technology!

- There are two things that have to be demonstrated: the specific chemistry or treatment innovation you are trying, and the mechanical system that is around it to make it go. It is not enough to test the specific technology itself without considering the effects on the surrounding system.

- Cooperative Extension and Soil Conservation Service are two analogous examples of organizations where good technology transfer takes place. These models could be valuable learning examples to help EPA with technology transfer.

- The more current EPA publications can be good sources for technology transfer; some of the regions are better than others about making them available, and making people aware of them. There needs to be more consistency among regions on their efforts to disseminate information, particularly to non-government employees.

- Land grant universities libraries and Federal depositories form cooperative repositories for which , when combined, can provide the bulk of the published literature on any particular subject. Often the barrier to access documents is only a perceived barrier; the seeker does not know where to start, particularly at the smaller operations level. It is also a question of the effort WWT staff are willing/able to put in to find the information they need. Also, Federal Deposit Libraries for government publications.

- There is some danger in using an "800" helpline, because many of the problems are complex, and do not have cookbook answers. But the information should be available to anyone in the public sector if it helps them reach compliance. The regulated community should have free access to information through the Internet to help them find information specific to their needs. While EPA is clearly making huge strides in this direction, the need for additional publications with guidance on use of

the Internet resources is in high demand in the public sector.

- The private sector needs incentives to want to make info available.

d. Alleviating federal regulatory barriers:

- EPA could continue to promote an industrial versions of Project XL (multi-media permitting process for a specific facility that extends deadlines and reduces penalties based on the "good faith" effort of the facility). The hotline for project XL is 703-934-3239.

- There needs to be a forum outside the regulatory one for permitters and permittees to meet to discuss situations. This needs to be voluntary, and will require additional resources, but savings would most certainly be realized on the back-end of the process when fewer enforcements/activities are needed and fewer permits are challenged.

- There needs to be an improvement in the way permits are processed in the permitting office. Routine permits can be handled by lower level staff, perhaps well trained support staff. More sophisticated permits should be directed to experienced professional engineers who can specialize in particular deeds. It was noted that in some states the permit writer is doing things he or she should not be doing, like checking grammar and spelling on permit applications, that offer nothing to the process itself.

- EPA and all stakeholders should avoid litigation as part of an enforcement action: once it starts, it can take years (Chicago: 7-10 years) for the final enforcement decisions to be made. There needs to be a different response mechanism where the permitter can enter into an intervention with an out-of-compliance facility to come up with a reasonable solution and plan of implementation, including pollution prevention measures that can help the permittee get back into compliance.

e. Alleviating state and local regulatory barriers:

- Industries could give environmental advocacy groups a share of any savings realized with the use of an innovative technology. This would promote community relations, help educate the public and build public trust. It would also get local activist groups in on the decision-making early on, and gain their "buy-in" to testing innovative technologies.

- States should create an Innovation Zone for permit writers to provide them safe latitude to work with those who would like to try an innovative technology. Allow them the flexibility to work with the permittee on compliance schedules and requirements during trial periods. While this would in some ways increase risks for all parties, it would even the risk among them.

- As with environmental activists, bring union representatives and citizens in on early decision-making and during trial runs of innovative processes so that they remain informed and included. This gains buy-in from local political and citizen forces, builds trust and flexibility into the effort, and gets the community in support of trying innovative technologies that may be cheaper to build and operate, or that may do a better job at cleaning up the water.

- Flexibility in compliance schedules for facilities that are testing innovative technologies should be applied, and the regulator needs to be willing and ready to defend that flexibility with the public. In this situation, the public bears some of the risk in the short-term, and they need to understand that the risk will be lessened in the longterm. This will require education of elected officials who may not be as receptive to long-term solutions.

f. Wiser allocation and use of funds:

- EPA or states should offer money that is directed at a very specific problem, e.g. Monsanto offered $1 million to anyone who could solve their ammonia problem. This offered challenge, incentive, and recognition to innovators.

- EPA should identify some highly specific areas where real solutions are needed, and then allow and encourage applications of innovative technologies to try to solve those problems, e.g. VOC emissions from manufacturing facilities.

- With money, the barriers will be redefined; you'd either leap over them or break through them. Every major breakthrough in technology had barriers, but nobody remembers them, e.g. Golden Carrot.

- Those who fund innovative technologies should go more for "bunt singles" than "homeruns" (e.g. the model used by NYSERDA for incremental development). This allows the field to push toward their objectives in small pieces.

- Ask the host site to come up with funds to partially support efforts. It buys ownership in the solution.

- Don't offer RFPs. Send out very focused requests for what is needed (e.g. Monsanto with ammonia). And keep paperwork for responding to the request to a minimum; sometimes the people with the best ideas don't know how to express them on paper.

Some Suggested Tactics for Encouraging the Use of Innovative Technology to Address Wastewater Pollution Problems

Specific tactical suggestions for improving the application of innovative technology to wastewater problems were made by focus group members. These suggestions enter into somewhat more depth than the strategies presented earlier in this report, enumerating in most cases specific steps that could be taken to alleviate the resistance to using innovative approaches and technology.

Presented below are some of these tactical suggestions in the same categories as the strategies were presented, i.e. risk, data and trials, technology transfer, federal regulatory barriers, state and local regulatory barriers, and lack of funding. There is cross-over, i.e. a tactic presented as a risk reduction tactic could also just as appropriately have been listed under the Technology Transfer category.

1. Tactics that would lead to Risk Reduction for Various Stakeholders:

* One way to reduce the inherent risk in using innovative technology is to more equally distribute that risk among the key stakeholders of the project. One municipality entered into an agreement with a developer that the community will put up the initial 50% costs of an innovative project for dealing with sludge, and the remaining 50% is held back until the technology proved itself. If the technology was successful, then the rest of the cost was paid the developer. If not, the city retained the remaining 50% and the used equipment, and the developer was held harmless (did not face litigation) for the failure. In short, the city was willing to assume half the risk because of the potential savings from not having to haul sludge if the innovative system worked.

* Perceived risk can be reduced by early and on-going education of community leadership. A number of cases were suggested where a municipality considering the use of an innovative technology for wastewater lowered or erased community-perceived risk by bussing or otherwise taking adversaries or potential adversaries to a site where the technology was actually being used. The feasibility of this approach depends on the distance a community is from the site where the innovative technology being considered is in place. Experts noted that this is a "localized" effort, and that acceptance of the technology drops off outside the easy commuting range.

* A variation on this approach was also given: in one community, residents were strongly against the use of an innovative technological land application approach because of perceived risks to the community's drinking water. The media had only heightened fears and resistance by voicing doubt about the technology. The movement against the use of the technology was being led by one individual, whose voice carried strong weight in the community's decision-making. The engineering consultant paid to fly the individual to the University of Pennsylvania, where the person met with academic experts on the technology, received a tour of the on-site working technology, and had all questions and doubts answered. That individual returned to her own community, and became a strong advocate for that technology's use, and convinced her neighbors of the value and acceptability of the technology.

* Establishing a citizen's advisory board was another suggested tactic for dealing with perceived risks and community resistance. Particularly getting environmental group members involved at early stages of decision-making is critical for gaining community support for innovative technological approaches to wastewater treatment. Numerous experts noted that natural land applications practices can be attractive to environmental advocates, and therefore an easier "sell", because the technology provides preserved open spaces (including "wetlands"). Critical to gaining community support is defining all adversaries up front, and working with them from the beginning.

* The traditional training and education of engineers is a leading factor in making them risk-averse. Engineering schools teach their students to be conservative. They also teach students to focus on high-tech solutions and approaches. Yet in waste treatment, in many cases low-tech, natural systems are the cheapest and most effective solutions to the problems. States are now beginning to require continuing education for engineer licensure. This requirement provides an opportunity to tactically adjust engineers' thinking by having permitting agencies work with schools to provide education in low-tech solutions, small community solutions and technology transfer courses. Engineering students are trained to be afraid of failure; yet engineers must be willing to risk failure in order to challenge convention and try innovative approaches.

* Tactics to effectively off-set risk include placing greater national focus on those events and awards that recognize consultant engineers who willingly seek innovative solutions to municipal and industrial wastewater problems. These

include the National Innovative Awards Program, state awards for innovative waste treatment system designs, and other recognition efforts that reward risk-taking and divergent thinking for the purpose of growing the field of wastewater technology.

* Small communities need risk reduction systems that protect them from potential failure of innovative technology. One suggested tactic is to establish an insurance package that would be in place to protect small communities from the risk of system replacement. An organization such as the Association of Towns could set up an insurance program that would provide fallback funding should a small community attempt to use innovative technologies, and the system ultimately fails.

* Increasing the number of stakeholders sharing the risk is a tactic to reduce the risk on any one or two stakeholders for a given system. One tactic for distribution of risk is the selling of treatment capacity to remove units of pollution from a given waterbody as generated by numerous dischargers. One plant, for example, could sell capacity to remove units of phosphorus (e.g. the town of Willsboro, NY buys phosphorus removal capacity from Plattsburgh, NY). This then changes the rules of who wins and who loses. With this, the regulator becomes a real stakeholder.

* The tactic of looking at a whole waterbody rather than one given industry or municipality changes the number of stakeholders and increases the number of agendas being served by pollution protection measures. For example, if protection of Clear Creek in Golden, CO is viewed only in terms of the pollutant discharges from Coors Brewing Co., the risk is concentrated on a small number of stakeholders. However, if all the towns along the creek, and all the mining operations that also lie on its borders, are actively included in protective efforts, the risk to any one entity is lowered, and the responsibility also is shared among many rather than a few. This tactic, i.e. broadening the geographic area of consideration, means: 1) increase the number of stakeholders; 2) make sure all the stakeholders are provisioned with the information they need to make reasoned decisions; 3) have stakeholders develop a system of division of risk; and 4) allow flexibility in the way each stakeholder meets their responsibility.

2. Tactics to Improve the Availability of Credible Data and Opportunities for Early Trials of Innovative Technology:

* A system for collecting long-term data on mechanical technologies would allow permit agencies to come up with badly-needed guidelines to evaluate that

technology. Presently a database is kept only as long as the contract is enforced. These mechanical technologies need to be followed with data collection, analysis and dissemination on a long-term basis. Consulting engineers would be the appropriate entity to overcome this database barrier, and the most logical group to continue long-term collection of data on mechanical systems they designed.

* A number of states are open to testing new technologies, e.g. GA, NC, MI. These states have the staff, and know their communities and what those communities'needs are. A tactical advantage could be gained by approaching the engineers and permit writers in these states to find communities in which to platform test innovative technologies to gather early and mid-stage data.

* A tactical move that could improve the available database on innovative technologies would be to link consultant engineers with academics working on these issues. An example of such a successful partnership is Clough-Harbor Associates and Clarkson University working together to introduce a constructed wetland in the municipality of Minoa, NY. By combining the "deep thinkers" with the "practitioners", more confounding problems could be explored to help find lower-cost, effective solutions to problems posed by conventional technology.

* Use the Internet to tactical advantage to share data on innovative technology trials and results.

3. Tactics to Improve Technology Transfer of Innovative Technology:

* Some states have developed clear guidelines and criteria for land application systems. Georgia, Pennsylvania, and Delaware were three notable states. There is, however, no consistency from state to state. Experts at the focus groups suggested that the development of national model guidelines and criteria would dramatically reduce the technology transfer barriers across state lines as well as reduce the risk to the consulting engineer, because engineers would be clear about basic requirements and expectations regardless of the state in which they were working. Experts suggested that the Water Environment Federation (WEF) would be an excellent group to lead the development of these guidelines and criteria, because they would bring the needed credibility to the process. It was suggested that WEF take the lead on collecting guidelines from the various states that have already developed them, and formulate a "model set" that could be peer reviewed, approved by the environmental advocacy community and regulatory bodies, and

then consistently applied across all states. The only differences in the guidelines and criteria would be based upon differences in geology and climate.

Experts listed some of the guidelines that could be included:

- types of characteristics an area of land must meet to be considered as a potential site.

- procedures for collecting additional information to further determine suitability of site.

- list of hindrances to successful land applications.

- different considerations that must be given based on climate, rainfall, evaporation rate, etc.

- suggested processes for collection of information needed to evaluate the site.

- information on areas of up-front costs that must be incorporated in initial decision-making.

Experts suggested that these guidelines and criteria focus on process and performance only in order to allow greatest flexibility in approach.

4. Tactics to Offset Barriers Created by Present Federal Regulatory Requirements:

* Experts suggested that a group such as the Water Environment Federation review some of the regulatory aspects and permit compliance criteria, and denote areas where change is needed to accommodate some innovative technological approaches, e.g. some technologies require a longer time schedule for reaching compliance. This process would allow the development of criteria for the notion of "soft landings", e.g., additional timeframes for meeting compliance in the case of innovative technology failure or shortcomings.

* Federal agencies have different roles: enforcement, technology transfer, systems review, etc. People become familiar only with their job requirements, and have little or no knowledge of the other aspects of wastewater regulation. A tactical approach

on the part of EPA would be to rotate people in these positions so that they begin to see the "whole picture". This would act to improve communications between the regulators and the regulated community, and would also open the door for greater flexibility and partnership between the two.

5. Tactics to Offset Barriers Created by Present State and Local Regulatory Requirements:

* Following the lead of, for example, Atlanta, GA, states and local entities could assemble a "municipal engineering group" that could review technical designs of proposed systems or permit writers and advise on feasibility of design. A major barrier noted by experts at the focus groups was the lack of apparent engineering knowledge and experience of permit writers in many states. This approach would provide permit writers with guidance and professional opinion on proposed systems, and as a result allow permit writers to be more flexible with permittees and more a partner in the implementation and oversight of the system than an enforcer. Such groups would be able to help permit writers determine, for example, the number of months a given system would need before it would be able to meet permit limits.

* The state of Georgia claims to have stabilized their state permits in a way which supports innovators. They determined what level of water quality was needed, and hold that level over decades, which effectively extends the life of the NPDES permit. This stability fosters trials of innovative technologies; if the permittee knows that the requirements won't change for the next 20 years, it allows much greater latitude and time to get an innovative system up and running, and into compliance before a new permit is needed.

6. Tactics to Surmount the Barrier of Lack of Funds:

* One of the causes of this barrier is the lack of real cost data - no one knows what systems cost, and cost comparisons between conventional and innovative systems cannot be done. A database of updated cost studies, with particular emphasis on alternative and innovative systems, needs to be the made available perhaps under the auspices of WEF.

* Government agencies should provide an infrastructure that allows people to try specific solutions to specific common problems. For example, New England Regional Office CEIT program looks at 10 ideas, and finds that 2 of them apply to

problems faced by 15% of their client base. EPA New England then provides 10% incentive funding as well as time to try out the solution and a location in which to try it out. The Regional Office could encourage other innovators to pursue the same problem. This provides a focus on problem-solving, and the government assumes the role of broker for new projects.

* EPA needs to offer more "golden carrots" such as they offered major refrigerator manufacturers to develop a CFC-free, energy efficient refrigerator. The money granted the developer was then used to provide rebates to consumers who purchased the refrigerator, which boosted the market for the manufacturer.

* EPA might work with WEF to identify the top 5 problems in wastewater, and make available $2 million to solve each of these very specific problems. The crucial point is focusing efforts of innovators, and specifying the preference for innovative solutions.

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